

*Innovative Technology Adoption in the
Norwegian Healthcare System:*

A Case Study from the Personalized Cancer Medicine

MSc in Innovation and Entrepreneurship

Xiaolin Wang

21.05.2013



*“Getting a new idea adopted,
even when it has obvious advantages,
is often very difficult.”*

By Everett M. Rogers

Diffusion of Innovations

Acknowledgments

This thesis is a partial fulfillment for the MSc degree in “Innovation and Entrepreneurship” at the University of Oslo. The research subject is proposed by the Oslo Cancer Cluster.

First of all, I would like to thank my supervisor associate professor Tor Borgar Hansen for interesting discussion, critical comments and professional guidance. I also would like to thank Anders Tuv and Jutta Heix, my internal co-supervisor at the Oslo Cancer Cluster, for giving me valuable suggestions and additional help through the whole study.

I am indebted to all of the informants. Thanks for your valuable time and sharing your experience and insights with me. Without your contribution, the study would not be possible.

I am grateful to Birthe Soppe for so many interesting discussions. Your passion for research has been always inspiring.

At last, I would like to thank my family and friends for your love and encouragement, especially to my dearest Tao. Thanks for always being beside me, trusting me and supporting me! To my dear Anton and Alex, you are such wonderful understanding kids. Thanks for giving me time and space for this study. I feel sorry for not being able to playing with you so much in the past few months.

Xiaolin Wang

21.05.2013, Oslo

List of Abbreviations

COP: Clinicians, Oncologist, Pathologists

HIIP: Highly Integrated Informatics Platform

NCGC: Norwegian Cancer Genomics Consortium

NCS: Norwegian Cancer Society

NRC: Norwegian Research Council

NSG: Nasjonalsatsgruppe

NTNU: Norges Teknisk-Naturvitenskapelige Universitet i Trondheim

OUS/UiO: Oslo University Hospital

PCM: Personalized Cancer Medicine

PEOU: Perceived Ease of Use

PU: Perceived Usefulness (PU)

TAM: Technology Acceptance Model

UiB: University of Bergen

UiT: University of Tromsø

WHO: The World Health Organization

Table of Contents

Acknowledgments.....	III
List of Abbreviations	IV
Abstract.....	VII
1. Introduction	1
1.1 Background about the Norwegian Healthcare System.....	1
1.2 Introduction to the Case of Personalized Cancer Medicine (PCM)	2
1.2.1 The Biology Context.....	3
1.2.2 Current Cancer Medicine.....	3
1.2.3 The Personalized Medicine and Technology	4
1.2.4 The Personalized Cancer Medicine (PCM) Status Quo in Norway.....	5
1.3 Research Questions and Objectives	6
1.3.1 Research Questions	6
1.3.2 Research Objectives.....	7
2. Theoretical Grounding.....	8
2.1 Innovation and Entrepreneurship	8
2.2 Technology Adoption.....	11
2.3 Technology Acceptance Model.....	13
2.4 Fit of Human, Organization and Technology Factors (HOT-fit)	15
2.5 Stakeholder Theory	16
2.6 Development of Propositions	19
2.7 Summary of the Theoretical Framework	20
3. Methodology.....	21
3.1 Research Design.....	21
3.1.1 Research Paradigm.....	21
3.1.2 Research Method	22
3.2 Selection of Participants and Data Collection.....	23
3.3 Data Analysis	25
3.4 Validity and Reliability	26
4. Results	27
4.1 Decision-making for PCM Technology Adoption	27

4.1.1	The Initiative from Entrepreneur-Oriented Researchers.....	27
4.1.2	Governmental Support.....	29
4.1.3	The Norwegian Approach to the PCM Adoption in Practice	30
4.2	The PCM Technology Acquisition/Development in Norwegian Healthcare.....	34
4.2.1	Technology	34
4.2.2	Human.....	37
4.2.3	Organization.....	41
4.2.4	Fit between Human, Organization and Technology	44
4.2.5	Broad Context	46
4.3	Roll Out-Cross the Chasm.....	47
4.4	Facilitators and Barriers	49
5.	Discussion and Conclusions	50
6.	Implications	61
6.1	Theoretical Implications.....	61
6.2	Practical Implications.....	61
7.	Further Research and Limitations.....	62
8.	References	63
9.	Appendix	66

Abstract

Health sector faces increasing pressure to provide quality service with limited budget. Adoption of innovative technology is a powerful solution to the problem. Technology adoption encompasses a range of inter-related complexity between technical, human and organizational factors involving multiple stakeholders. Different technologies may be adopted through different pathways in a specific healthcare system. There is not much empirical data and theoretic findings regarding how innovative technology is adopted in Norwegian specialist health care.

Personalized Cancer Medicine (PCM) is an innovative technology transforming cancer patients' care, which is currently adopted in Norway. PCM adoption represents a typical case for technology adoption in the Norwegian specialist health care and it is worth documenting and analyzing.

We have conducted a descriptive and exploratory single qualitative case study about this contemporary project in its real-life context. Through conducting in-depth interviews with stakeholders, participating meetings/debates, and analysis of documents and scientific publications, we provide an in-depth longitudinal description of PCM adoption in Norway.

In this thesis, we find evidence supporting that new technology adoption in healthcare is in response to both exogenous and endogenous stimulus and actions. The user perceived usefulness of this technology for resolving an important societal problem stays centrally for the possibility of adoption. The nature of the technology concerned and its intersecting with the specific local adoption system largely influence the adoption trajectory. Researchers with high entrepreneurial-orientation (EO) in healthcare system have an indispensable role in decision-making, strategy articulation and implementation as both managers and technology champion. A top-down, coordinated program with public fund can be an effective strategy for adoption of innovation towards a high-end use in the Norwegian decentralized healthcare system. Facilitators and barriers for PCM adoption are identified. This extensive descriptive information may be useful for portraying a rather complete picture to inform further managerial actions for PCM implementation.

1. Introduction

Health sector faces tremendous pressure to provide better service with less money. Adoption of innovative technology is a powerful way to enhance productivity and efficiency, thus providing a remedy to tackle the challenge. There is however insufficient empirical evidences and theoretical researches regarding the adoption of innovative technologies in the Norwegian healthcare system. Personalized Cancer Medicine (PCM), which transforms cancer patients' care to an individualized treatment based on the patients' genomic information, is one of the innovative technologies currently adopted by the Norwegian health care system. In this study, we present empirical evidence through studying the process of PCM adoption to provide information for managerial actions for future PCM technology implementation and shed light for further theoretical research.

1.1 Background about the Norwegian Healthcare System

Better and equitable health is a global aspiration. The ultimate goal of any health care system is to better the health for all. A healthcare system is defined, according to The World Health Organization (WHO), as “the arrangement of all organizations, institutions and resources devoted to produce actions whose primary intent is to improve health”. Healthcare systems vary all over the world, but with three elements common to all health care systems: financing, reimbursement, and production or delivery.

Norwegian health care system is mostly publicly funded through tax-based funding and has a large proportion of public governance. The central government provides grants to the counties who reallocate finance to the hospital sector. The state-run National Insurance Scheme (NIS), created in 1967, offers public insurance against individual medical expenses (fees-for-service) for ambulatory care provided by hospitals and private practitioners. All public hospitals run by four Regional Health Authorities (RHA) owned by the Ministry of Health and Care Services (Hagen and Kaarbøe, 2006). The proportion of private actors is relative small, and few people have private health care insurance. Norwegian healthcare has a goal of equity in health without compromising universalism. All citizens are eligible for treatment free of charge in the public hospital system and all citizens have the right to Free Hospital Choices (The Patients' Rights Act,

1999). The Norwegian Health Care System was ranked number 11 out of 190 nations by the overall performance in a report from WHO (world health report, 2000).

The healthcare is a substantial part of the public sector in Norway. According to statistics, nominal general governmental expenditures in the healthcare in Norway for the year 2010 was around 17 % of total costs (ssb.no, 2010) and was ranked as the second highest expenditure among all the sectors in Norway. Some of the recent researches show that this high cost is largely due to the relatively lower productivity in specialist health care as compared to other Nordic countries (Kittelsen, 2009). The healthcare expenditure is expected to be continuously increasing in the next couple of decades, which imposes a pressure on the country's welfare sustainability. Such forecasts bring out the questions on how to use the available resources to provide the population with more/better health care services through enhancing productivity and efficiency, so that hospitals are able to produce more output with the same amount of inputs.

Adoption of innovative technology is a powerful way to enhance productivity and efficiency. Innovative technology in healthcare has significantly enhanced accuracy and effectiveness of the diagnosis and treatment (Lemieux-Charles, 2006). However, despite of rich evidence-based technological advances, there is moderate progress in technology adoption in healthcare comparing to other industries (Lemieux-Charles, 2006), which is partly due to the great organizational complexity in healthcare system.

Within the complex, decentralized Norwegian healthcare, how an innovative technology can be adopted in specialist health care for the whole population? There are not many theoretical and empirical researches focusing on this aspect. Personalized cancer medicine represents a transformation on modern healthcare and provides a good context for the study of this question.

1.2 Introduction to the Case of Personalized Cancer Medicine (PCM)

This section introduces the context where the case of PCM is embedded in and defines the frame for this study.

1.2.1 The Biology Context

A gene carries genetic information of a living organism, which can be inherited by the next generation. In human beings, a gene is a sequence of deoxyribonucleic acid (DNA) packed in a chromosome. This DNA sequence can be transcribed into RNA (another type of nucleic acids) and the corresponding protein will be synthesized based on the RNA sequence. Protein is the functioning unit of our body. Therefore, genetic information flows following a DNA--RNA--protein dogma. Often a change in DNA sequence - known as mutation- will lead to a change in its resulting protein and leading to a malfunctioning protein. The accumulation of the critical changes in DNA and thus malfunctioning protein will lead to diseases, among those the cancer. In worst case, a single change in DNA and protein can cause diseases. Every cancer patient has a unique combination of DNA mutations-every tumor has various mutations and the same gene can be mutated in different tumors. When critical mutations are inherited, next generations will have increased prognosis to certain diseases. Accumulation of molecular abnormalities in tumorigenesis has allowed further sub-classification of many cancer types (Pleasance et al., 2009).

1.2.2 Current Cancer Medicine

The current cancer treatment is generally practiced at a principle of one-drug-for-all- patients, although some patients may receive drugs targeting the mutation on a single gene. In principle, most modern cancer molecule drugs are designed to target and block the malfunctioning mutated protein, thus controlling cancer progression. However, when the drugs are used at one-for-all principle, the drug will not work efficiently for most patients and might cause unnecessary side-effects, as most patients get a drug targeting a protein in which there is no mutation and not the cause of the disease for the patient. This traditional practice is thus not for the patients' best benefit and costs unnecessarily extra for societal healthcare. This traditional practice needs to be improved. With personalized medicine, we can pinpoint at the exact gene mutations, that are the disease causes, and specific drugs targeting these mutations can be administrated for the best patient benefit. Some scholars argue that within the next 20 years, the advances in cancer medicine could transform cancer from a death warrant to long-term health management (RIFAT et al., 2007).

1.2.3 The Personalized Medicine and Technology

The modern healthcare stands at the transformation threshold from the traditional disease event focus to Predictive, Preventive, Personalized and Participatory Medicine (P4M) for meeting each individual's specific health needs, as coined by Dr. Hood eight years ago (Hood, 2004). This transformation is rooted from the well-established principle that each individual is born with unique inherited genetic characteristics, while a great deal of individual's genome is shared by all humans. The variations result in each person's unique susceptibility and resistance to various diseases. The transformation to P4M is facilitated rapidly by advances in science and technology. Innovative tools/technologies for P4M have been developed, which enable the prediction of health risk, quantifying disease development and providing guidance to the targeted therapeutic approaches (Hood et al., 2004). P4M focuses on the integrated diagnosis, treatment and prevention of disease in individual patient by integration of new approaches to disease diagnosis, new measurement and visualization technologies, computational and mathematical tools. P4M provides new abilities to detect disease at an early stage; stratify patients into groups that enable the selection of optimal therapy, thus reduce adverse drug reactions (Hood, 2008). With exemplary evidence-based knowledge and know-how, P4M has now been approved in practice and envisioned as a major revolution in healthcare, which will over the next few years replace the traditional reactive mode of medicine—where we wait until the patient is sick before responding. When this is aligned with appropriate healthcare resources, it can be used for any health objectives ranging from health promotion to chronic disease management. There have been many initiatives for developing P4M at national, regional and sector levels across the world, such as in US, Canada, UK and Netherland.

For the simplicity, personalized medicine is defined as “a form of medicine that uses information about a person's genes, proteins, and environment to prevent, diagnose, and treat disease” (Hood, 2008). Implementation of personalized medicine in clinic requires an Integrated Health-Information Platform consisting of a sequencing technology and highly integrated bioinformatics software (HIBS). With this HIBS, the patients' DNA sequence data obtained from the sequencing instrument can be assembled; disease-cause gene can be identified. This information will direct clinicians for diagnosis,

prescription and patient follow-up, and a patient-centered personalized medicine is practiced at molecular level.

1.2.4 The Personalized Cancer Medicine (PCM) Status Quo in Norway

In 2010, there are 28271 new cancer cases registered in Norwegian cancer registry. The incidence rate has increased by 7 per cent for men and 3 per cent for women from the past five-year period (2001-2005) to the current one (2006-2010) (Cancer registration, 2012). Cancer research is the first priority according to Norwegian research council. In order to bring the personalized medicine into reality to benefit all the citizens, cancer treatment is the initial strategic focus of P4M practice in Norwegian healthcare. The Norwegian government has recently set up a temporary financing scheme for this purpose (Norwegian Health directorate, 2012). A total governmental investment of 75 million NOK has been placed at the first stage for PCM technology adoption towards both clinic and research use in hospitals.

The vision is to develop a national platform providing knowledge-based individualized cancer therapy, encompassing screening, diagnosis, prognosis, prediction of treatment efficacy, patient follow-up after treatment, early detection of recurrence and stratification of patients into cancer subgroup categories for target treatment. This regime will allow physicians to see early warning signs of malignancies and take early action for targeted therapy based on patients' genomic information. People could adjust their lifestyles accordingly to prevent disease.

This technology is disruptive to Norwegian healthcare in the way that it applies an innovative technology to the field of cancer patient management, namely it is a new clinical use of this innovative technology in Norwegian healthcare. This will transform the traditional disease event-focused medical care to a personalized and preventive care. This is a coherent model of health prevention, cancer avoidance and targeted treatment, which challenges so much of the conventional wisdom and institutional complacency and requires engagement at multiple levels of health care system—from policy maker, managers, and scientists to physicians.

Currently, PCM has been adopted in four national health regions with established sequencing technology platform in OUS/UiO, UiB, NTNU and UiT. Clinical sequence data has been collected through pilot clinical trials in collaboration between clinicians and scientists in the regional sequencing platform. This data will compose a national mutation database and register in cancer registry. This database serves as a valuable dataset for further cancer biology research and drug discovery.

In this study, we have followed the technology adoption over time (from the earliest initiative in 2011 to 2013) in Norwegian healthcare system, with focus on exploring some particular aspects of the adoption lifecycle in detail. All the national events related to PCM adoption are included in this study and collectively defined as “the case for personalized cancer medicine in Norway”. Due to the time limitation, the study will be focused only in Oslo region. An expansion of this study to include all four health regions in the Norway would be left for future exploration.

1.3 Research Questions and Objectives

1.3.1 Research Questions

The national strategic goal of personalized cancer medicine (PCM) is to provide evidence-based, patient benefit and cost-effective treatment to cancer patients inhabited in Norway based on the patient’s genomic information. PCM innovation is complex involving multi-disciplined collaboration of major constitutions in healthcare (patient, clinicians, administrators and researchers) and partnership of disciplines (i.e. bioinformatics, biologist, information technologist, statisticians, physicians) and organizations (i.e. drug and device firms, healthcare agencies, information technology firms and academic medical community)(Chiang A. , 2011 and Snyderman R. 2012). Due to the range of inter-related complexity between technical, social and organizational factors, adoption and implementation of innovative technology in healthcare is notoriously difficult. The adoption is not a straightforward linear process, but rather a dynamic one, as the technical, social and organizational factors are gradually aligned (or not) over time in the context (Cresswell and Sheikh, 2012). Generally, adoption of a technology requires reinvention of the technology or a specific model under specific cultural and organizational context. Currently there is no available complete model that

Norwegian health care system can apply from. In addition, there has not been much theoretical research on the Norwegian health care system regarding innovative technology adoption.

This PCM program represents a typical case for technology adoption in Norwegian specialist health care. It is a case capturing the circumstances and conditions of a common situation and could be functioning as a test ground for theoretical propositions and model building. It is of timely importance to investigate *how this innovative technology-personalized cancer medicine is adopted in Norwegian healthcare?* An extensive collection of such descriptive information will be useful for portraying a somewhat complete picture, which facilitates further managerial actions. The experiences from this study may be informative for the future technology adoption. Other specific research questions include:

- How various technical, human, social and organizational factors are involved and influencing technology adoption in Norwegian healthcare?
- What aspects of Norwegian healthcare are unique and how do these influence PCM technology adoption?
- How the inter-interaction of technical, human, social and organizational dimensions evolved along the process? How are they aligned (or not) until now?

1.3.2 Research Objectives

Based on a thorough study of the PCM adoption in Norwegian healthcare system, this study is aiming:

- To describe a model for innovative technology adoption in Norwegian healthcare
- To identify the key technological and organizational facilitators for successful adoption of PCM technology in Norwegian healthcare
- To identify the barriers or missing links for technology adoption and diffusion in Norwegian healthcare
- To provide a basis for interventions (i.e. training and model refinement) for managerial act to increase user acceptance and more efficient technology adoption

2. Theoretical Grounding

This section presents literature review on the following topics: innovation and entrepreneurship, technology adoption, technology acceptance model, fit of human, organization and technology, as well as stakeholder theory. These theories altogether set up a framework for analyzing the innovative technology adoption in healthcare system. Some propositions are developed based on these theories.

2.1 Innovation and Entrepreneurship

Scholars have different views about innovation (Mises, 1949, Schumpeter, 1941, Bower and Christensen, 1995). According to Schumpeter (1941), innovation is the critical driver of economic change. He classified innovation into the following five 'types': new products, new methods of production, new sources of supply, the exploitation of new markets and new ways to organize business. Generally speaking, Schumpeter refers innovation as the new combinations resulting in the changes for the product production and function. This concept of innovation is more or less restricted to radical changes with a great impact on the industry sectors or business cycles. The minor day-to-day technical improvements are regarded as less important. Disruptive technology is a type of radical changes. A technology is regarded as disruptive when its utilization generates products with different performance attributes that may not have been valued by existing customers (Bower and Christensen, 1995). These new values can be created through the "different" nature of an existing technology or a radically new technology. Bower and Christensen favor the view of "different" nature of technology, emphasizing that they may not be radically new from a technology point of view, but have superior performance in the critical dimensions of customers' value (Bower and Christensen, 1995). While others argue the radical newness is an important element in this definition (Lynn et al., 1996). Despite the existence of these two views, disruptive technology will change the unusual products/technology paradigms and enables discontinuous products, process of services to provide customer-perceived exponential values (Lynn et al., 1996, Veryzer Jr, 1998).

These technological innovations thus give capitalist economies the peculiar dynamics through a process of "creative destruction", which could provide better results than the invisible hand and price competition.. Innovation adoption will mean the process

of bringing inventions into use. As perceived by Rogers (Rogers, 2008), adoption is “a decision to make full use of an innovation as the best course of action available,” and the process elements of adoption occur before or after the decision.

In healthcare, innovation is defined as those changes that help health practitioners focus on the patient by helping healthcare professionals work smarter, faster, better and more cost effectively (Thakur et al., 2012). Adoption and implementation of those best-demonstrated successful practices will change the performance of the organization. However, adoption of innovation in healthcare system is extremely difficult, because this process not only depends on the stakeholders’ perceived consensus benefits of the innovation, but largely relies on the contextual environment where the adoption should occur (Atun et al., 2010). The context may be external environment, such as government regulations, market trend and the safety compliance; or internal environment, such as organizational structure and culture, top-management decision-making process (Yarbrough and Smith, 2007, McFarland and Hamilton, 2006).

Entrepreneurship is a fast growing field and the entrepreneur is widely accepted as a fundamental economic agent driving economic development (Mises, 1949, Schumpeter 1941). In a broad definition, entrepreneurship is an activity that involves the discovery, evaluation, and exploitation of opportunities to introduce new goods and services, ways of organizing, markets, process, and raw materials through organizing efforts that previously had not existed (Venkataraman, 1997; Shane and Venkataraman, 2000). All “those situations in which new goods, services, raw materials, and organizing methods can be introduced and sold at greater than their cost of production” are regarded as opportunity and treated as objective phenomena. Research fields within how the entrepreneurial role should be incorporated into economy and strategy and how an entrepreneurial opportunity is identified remain hot topics.

In Schumpeter’s theory, entrepreneurial activities are interconnected with dynamics of innovation (Hagedoorn, 1996, Schumpeter, 1941). Schumpeter proposed that in the period of entrepreneurial capitalism, entrepreneurial activity is seen as the third factor of production in addition to the land and labor. “The” entrepreneur is the individual who carries out the new combinations and introduces the innovation, hence regarded as the only agent for economic change. Entrepreneurs are by definition neither inventors,

capitalists nor a social class, although they all can be combined in one person. While in the period of modern trustified capitalism, agents that drive innovation and the economy are large companies, which have the resources and capital to invest in research and development. In the large companies, “the entrepreneur is not necessarily an independent economic agent, but can be an employee of the large company with an entrepreneurial function” (Hagedoorn, 1996, Schumpeter, 1941). This entrepreneurial function is often filled cooperatively at large scale. In another word, the role of the entrepreneur is analyzed in terms of the function in the large company, and not necessarily at a physical person (Hagedoorn, 1996). In modern capitalism, the entrepreneurial activities can thus range from a single-person to a collective entrepreneurial function in large companies. The latter can be referred to intrapreneurship, where employee takes initiatives in organizations to undertake something new, without being asked to do so. Intrapreneur integrates risk-taking and innovation approaches to creatively transform an idea to a profitable venture and better performance within the organizational environment.

Knightians describe entrepreneurship as the exercise of judgment regarding an uncertain future. The entrepreneur’s role is to arrange or organize the capital goods he/she owns. Hence, opportunities are manifested in entrepreneurial action, namely the exercise of judgment over the arrangement of heterogeneous assets. Resource owners, by the nature of ownership, possess fundamental judgment rights and are treated not as passive suppliers of capital, but as critical decision makers.

Foss and Klein describe entrepreneurship as a creative team act in which heterogeneous managerial models interact to create and arrange resources to produce a collective output that is creatively superior to individual output (Foss et al., 2008, Foss and Klein, 2008). He emphasizes that entrepreneurial judgment and the recognition and enactment of opportunities may be derived from social processes such as dynamic interactions among team members’ heterogeneous mental models. In contrast to Schumpeter and Knight, Foss proposed a subjectivist approach to entrepreneurship in which the team, rather than the individual entrepreneur, is the unit of analysis and the team’s capital and resources are the key determinants of entrepreneurial activity (Foss et al., 2008), thereby bridging up the entrepreneurship and strategic management.

There are different views about entrepreneurial opportunity. Kirzner and others regarded the entrepreneurial opportunity as an entirely exogenous arbitrage objective phenomenon and is waiting to be discovered by alerted people. In this discovery theory, Kirznerian offer no theory of how opportunity is discovered and who identifies it; whereas in creation theory, opportunity is not an objective phenomena formed by exogenous shock to an industry or market. Rather, they are created endogenously by actions and enactment of entrepreneurs exploring ways to produce new products or services (Alvarez and Barney, 2007).

Entrepreneurial orientation (EO) is one of the most important and established concepts within the field of entrepreneurship. EO is generally consisted of the five facets: competitive-aggressiveness, risk-taking, innovativeness, proactiveness, and autonomy (Lumpkin and Dess, 1996). EO provides critical insights into questions of organizational-level strategy and performance. The attitudes and behaviors related to EO have been positioned as organizational phenomena that capture firm-level entrepreneurial patterns and processes (e.g Lumpkin & Dess, 1996, 2001). Walse and others have suggested that the manifestation of EO across organizational sub-units, from large strategic business units to small individual departments, also matters (Wales et al., 2011). EO is manifested within firms such that entrepreneurial attitudes and behaviors “pervade the organization at all levels” (Covin and Slevin, 1991).

2.2 Technology Adoption

Technology adoption generally refers the process by which an innovative technology is selected for use and then incorporated into daily use by an individual or an organization. This adoption normally progresses along sequential stages, proposed by Bohlen, Rogers and others (Beal and Bohlen, 1957, Rogers, 2008), of awareness, interest, evaluation and trial. Through this process, the individual or organizations make decision to adopt or reject the technology. The process of adoption over time follows a classical normal distribution or "bell curve", as figure 1 (Rogers, 2008). The adopters can be categorized as innovators, early adopters, early majority, late majority and laggards, according to the demographic and psychological characteristics of defined adopter groups. These five categories are summarized:

- Innovators –more educated, more prosperous and risk-oriented
- Early adopters – younger, more educated, tended to be community leaders
- Early majority – more conservative but open to new ideas, active in community and influence to neighbors
- Late majority – older, less educated, fairly conservative and less socially active
- Laggards – very conservative, oldest and least educated

The first group of people to use a new product is "innovators," and the last group to eventually adopt a product is called "laggards." Each adopter's willingness and ability to adopt an innovation depends on his awareness, interest, evaluation and trial.

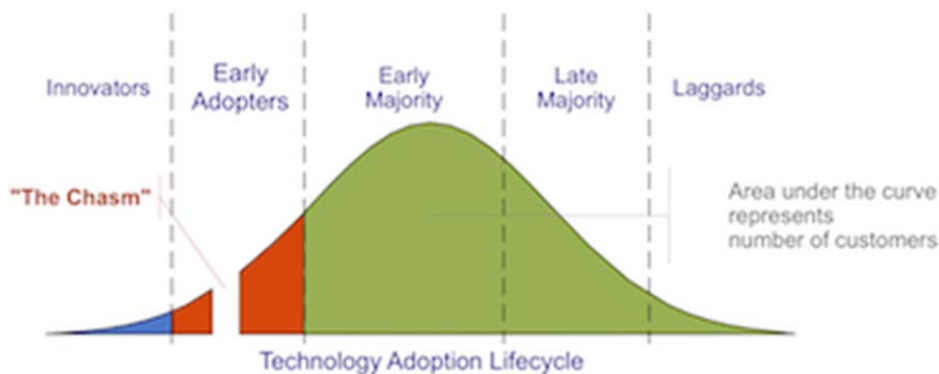


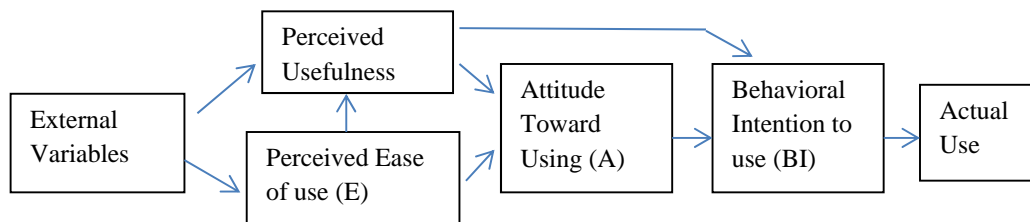
Figure 1

Geoffrey Moore (Moore, 2002) begins with the diffusion of innovations theory from Everett Rogers, and argues there is a chasm between the early adopters of the product (the technology enthusiasts and visionaries) and the early majority (the pragmatists). Making the transition between visionaries (early adopters) and pragmatists (early majority) is the most difficult step. Moore believes visionaries and pragmatists have very different expectations, and he attempts to explore those differences and suggest techniques to successfully cross the "chasm". Moore suggests that creating a bandwagon effect in which enough momentum builds will facilitate a technology/product becoming a de facto standard. However, Moore's theories are only applicable for disruptive or discontinuous innovations. Confusion between continuous and discontinuous innovation is a leading cause of failure for high tech products.

Technology adoption research is a mature field with many different models, such as Rogers's innovation diffusion theory (Rogers, E.M. 1995), theory of planned behavior (Ajzen, 1985) and Technology Acceptance Model (TAM) (a review by Venkatesh, 2007). This adoption process can be related to the scale of innovation efforts by distinguishing between macro-level theories and micro-level theories. Macro-level theories focus on the institution and systemic change initiatives. Innovation typically involves broad aspects of curriculum and instruction and might encompass a wide range of technologies and practices. Micro-level theories, on the other hand, focus on the individual adopters and a specific innovation or product rather than on large-scale change. Technological innovation in healthcare requires expertise in technical considerations and clinical practice, changes in organizational dimensions (Cresswell, 2012, Stockdill, S.H, 1992, and Rogers, E.M. 2008). Therefore, to successfully facilitate technology adoption in healthcare must address technical, cognitive, emotional, and contextual concerns.

2.3 Technology Acceptance Model

Technology Acceptance Model (TAM) is the most influential model, originally proposed by Davis FD in his doctoral thesis in 1986 (Davis et al., 1989). Other models for technology adoption are quite similar and fine-tuned from TAM. TAM is initially meant to explain the user acceptance in computer science. This model is commonly employed for describing an individual's acceptance of information systems (Davis et al., 1989). TAM assumes that an individual's information systems acceptance is determined by two major variables: Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) and the model can be depicted as Davis proposed (Davis, 1989):



The robustness of this model has been demonstrated by different applications to different technologies under different situations with different control factors and different subjects. A number of extended variables were proposed through the

progression of TAM research and summarized in Lee's extensive review article (Lee et al., 2003), which among others include relative advantage or value compatibility, complexity, observability, trialability, visibility and social influence.

- Relative advantage or value: the degree to which an innovation is perceived as better than competing products.
- Compatibility: the degree to which an innovation is perceived to be consistent with the existing values, experience and needs of potential adopters.
- Complexity: the degree to which an innovation is perceived as being difficult to use or understand.
- Trialability: the degree to which an innovation can be experimented with on a limited basis. An innovation that is trialable represents less uncertainty for potential adopters, and allows for "learning by doing".
- Observability: the degree to which the results of an innovation are visible to others. The easier it is for others to see the benefits of an innovation, the more likely it is to be adopted.

With extensive over three decades' research, TAM has been demonstrated as an efficacy theoretical model with good generalizability and predictive validity (Venkatesh et al., 2007). One example is its extensive application in psychology and organizational behavior (Benbasat and Zmud, 2003, Whinston and Geng, 2004).

Although TAM has been applied to hospital information adoption previously, scarcity exists in empirical studies in research of adoption and implementation of innovative technology in healthcare, especially surrounding the organizational issues, which is in part due to the lack of "coordinated efforts toward more theoretically-informed work" (Cresswell, 2012).

As PCM is partly manifested as a high integrated informatics platform to clinicians and biologists, so in this study we will take advantage of TAM for information science and organizational behavior research and then extend TAM theory to study the organizational issues in technology adoption. This will be done through the analysis of users' PU and PEOU at individual level and identifying successful/limiting factors for adoption embedded in the organizational and social dimension. In combination of the

notion of “fit” (Ammenwerth et al., 2006), we can further analyze how these factors interact with each other, and will emphasize the better fit among technical, social and organizational dimensions, the more likely a successful adoption will be assumed.

2.4 Fit of Human, Organization and Technology Factors (HOT-fit)

A human, organization and technology-fit (HOT-fit) framework was developed through a comprehensive literature review and extensive model validation in the field of innovation of health information system (HIS) (Berwick, 2003, Yusof et al., 2007). The model addresses categories of the HOT factors and interrelated dimensions, and points out that a mutual alignment will more likely ensure a successful adoption and implementation of an HIS innovation.

HOT-fit incorporates user’s satisfaction and system use as human elements (Yusof et al., 2008). User’s satisfaction is defined as overall evaluation of a user’s experience in using the system and is often related as a measure of system success. System use is concerned with the frequency and breadth and can be related to the persons who use it, their levels of use, training, knowledge, belief, expectation and acceptance or resistance (Yusof et al., 2007). Different types of systems can have particular functions and users, there may exist various type of resistance, such as people-oriented, system-oriented and interaction-oriented (Jiang et al., 2000). People-oriented resistance is the results from user’s personal characteristics such as age gender, background, value and beliefs, which can influence the individual’s attitudes towards to the technology. System-oriented resistance is related to system design factors or relevant technology including user interface and system characteristics. Interaction between people and system can result in interaction resistance.

The very nature of a specific healthcare system can be determined by its structure and environment (Cresswell and Sheikh, 2012, Anderson, 1997). Organization structure is described as type and size, culture, politic, hierarchy, autonomy, strategy, management and communication. The environment of the healthcare organization is consisted of its financing source, government, politics, localization, competition, inter-organization relationship and population served.

System quality is central technology element and is often related to the system performance and interface. In healthcare setting, measure of system quality includes ease

of use, ease of learning, response time, usefulness, availability and security (Yusof et al., 2008, Anderson et al., 1993). It is important to determine if the system 1) meets the needs of the projected users; 2) is convenient and easy to use; 3) fits the work pattern of the intended professionals. Information quality is often subjective from user's perspective regarding information completeness, accuracy, legibility, availability and reliability (Yusof et al., 2008, Anderson et al., 1993). Service quality is concerned with overall service delivered from both internal and external. It can be measured through technical support, responsiveness and follow-up service.

Net benefit captures the balance of positive and negative effects on its users, either on individuals or on organizational performance. The individual impact is related to the changes in behavior, user task, work activity and productivity. The organizational impact is the effect on the organizational performance. In healthcare, clinical outcomes are used as measurement of the benefit and can be quantitatively measured through cost reduction, improved efficiency in patient care, mobility (the rate of incidence of a disease) and mortality (death rate); or qualitatively measured as quality of care, impact on patient care and communication. Some barriers to HIS adoption by physicians are identified, including low level of IT expertise, lack of acceptance and alteration of traditional workflow.

2.5 Stakeholder Theory

The stakeholder theory was proposed in a strategic management book by Freeman in 1984. He proposed that a corporation has to create values for all the stakeholders as whole, not in separation. The success is made by all the stakeholders together and all stakeholders can create values that anyone of them cannot create in isolation. All individuals/entities involved in or influenced by a project can be viewed as a stakeholder and they can be internal or external. This theory refocuses decision-making power and the benefits of labor from those who invest money (stockholder) to stakeholders broadest defined as “any group or individual who can affect or is affected by the achievement of the activities of an organization” (Freeman, 1984). For a simplest summarization, stakeholder theory studies “The principle of Who and What really counts”(Walsh, 2005, Freeman, 1984). Stakeholder can include governmental bodies, political groups, communities, financiers, suppliers, employees, and customers and their status are

derived from their capacity to affect the firm and its other morally legitimate stakeholders. The nature of stakeholders is richly described in the academic literature (Friedman and Miles, 2002). Various ways in identifying stakeholders have emerged such as behavioral, ecological, institutional and resource dependence theory (Post et al., 2012, Freeman, 1984, Wood and Jones, 1995). However, none of single attribute within these theories can guide us to reliably separate stakeholders from nonstakeholders, and to explain whom and what a manager should pay attention to. Mitchell (Mitchell et al., 1997) proposed a theory of stakeholder salience and developed a typology, which permits the explicit recognition of situational uniqueness and managerial perception to explain how managers prioritize stakeholder relationships. In the typology, stakeholders can be identified by their possession of attributes among power, legitimacy and urgency. Stakeholder salience- defined as the degree to which managers give priority to competing stakeholder claims- is positively related to the manager perceived cumulative number of stakeholder attributes.

Power is defined as a relationship among social actors in which one social actor, A, can get another social actor, B, to do something that B would not have otherwise done. Power in the organizational settings can be characterized based on the type of resources used to exercise the power as: coercive power, based on physical resource; utilitarian power, based on the material or finance resource; normative power, based on the symbolic resource (Etzioni, 1964). Therefor a party with a power in a relationship could use these resources to impose its own will in a relationship. The access to those resources is not steady, thus the power is transitory as well.

Legitimacy is loosely referred to socially accepted and expected structures or behaviors, often is implicitly coupled with the power for evaluating the nature of relationships in society. Suchman (Suchman, 1995) suggested an evaluative, cognitive and socially constructed nature of broad-based legitimacy by defining legitimacy as “a generalized perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, and definitions”. This definition implies that legitimacy is a more shared perception within a societal system and it may be defined at various level of social organization.

Urgency is defined in dictionary as “calling for immediate attention” or “pressing”. Urgency exists only when two conditions are met: (1) when a relationship or

claim is of a time-sensitive nature and (2) when that relationship or claim is important or critical to the stakeholder. Based on the time-sensitivity and criticality, urgency is defined as degree to which stakeholder claims call for immediate attention. Urgency is perceived as the catalyst element for capture of the stakeholder-manager dynamic relationship (Mitchell et al., 1997). The concept of paying attention to relationships between stakeholders in a timely manner has been the focus of management issues (Wartick and Mahon, 1994). Mitchell (1997) has identified 7 classes of stakeholders based on the combinational possession of one, two or all three attributes: power, legitimacy and urgency, as illustrated in Figure 2. They provide a framework for understanding how a stakeholder can gain or lose salience to a firm's managers and lay ground for analysis of dynamic nature of stakeholder-manager relationships.

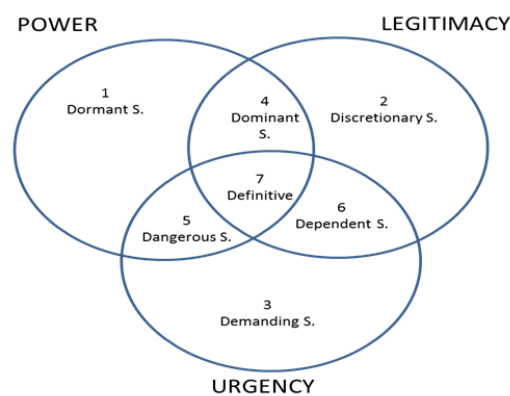


Figure 2.

The salience of a particular stakeholder to the firm's management is low if only one attribute is present; moderate if two attributes are present; and high if all three attributes are present. Stakeholders can change in salience, by requiring different degrees and types of attention depending on their attributed possession of power, legitimacy, and/or urgency, and levels of these attributes, thereby salience can vary from issue to issue and from time to time. This model added dynamism to the static maps of a firm's stakeholder environment enabling a more systematic sorting of stakeholder-manager relationships as these relationships attain and relinquish salience in the dynamics of ongoing business. In addition, model permits managers to map the legitimacy of stakeholders and therefore to become sensitized to the moral implications of their actions

with respect to each stakeholder. Thus, these refinements contribute to the potential effectiveness of managers as they deal with multiple stakeholder interests.

By employing agency theory, Hill and Jones (Hill and Jones, 1992) have developed a stakeholder-agency theory and proposed that managers have the responsibility to reconcile divergent interests by making strategic decisions and allocating strategic resources in a manner that is most consistent with the claims of the other stakeholder groups. This model was based on the fact that the managers have a unique position at the center of the nexus of contracts, namely they are the only group of stakeholders who enter into contractual relationships with all other stakeholders and who also directly control over the decision-making apparatus of the firm (Hill and Jones, 1992). Therefore the characteristics of managers are vital for a manager to identify the stakeholders, to decide which stakeholder is salient to the firm and which stakeholders should receive management attention. Stakeholder salience is positively related to the manager perceived cumulative number of stakeholder attributes.

2.6 Development of Propositions

Drawing on the theoretical foundation presented here, we realize that healthcare is an adaptive system and technology adoption in healthcare intersects with a broad embedded context (technology, human and organizational context), which together will determine multi-faceted nature of the actual process of technology adoption in a specific healthcare system. We propose propositions:

Proposition1: New technology adoption in healthcare is in response to an exogenous and endogenous stimulus and actions. The entrepreneurial-oriented scientists perceive the opportunity and proactively promote the technology adoption. The user perceived usefulness of this technology for resolving an important societal problem stays centrally for the possibility of adoption.

Proposition2: The characteristics of the technology and nature of the problem being addressed will determine the pattern of adoption through a manner of intersecting with a specific adoption system and the broad context.

Proposition3: The technology champion advocating an innovative technology is at the center nexus of early technology adoption in the Norwegian healthcare.

Proposition4: The alignment of stakeholders' perceived benefit in a broad context will influence the trajectory of technology adoption.

2.7 Summary of the Theoretical Framework

Based on the propositions, the framework of the study can be summarized as following:

The dependent variable for measuring PCM technology adoption is the actual use of the technology in the Norwegian healthcare system.

The independent variables are the factors which have influence in the process of technology adoption and defined in the theoretical grounding part, including the nature of the problem being addressed, characteristics of healthcare, finance, human, technology, organizational, ethic perspectives and broad context such as government policy and national strategy.

The control variables are all national influential factors, which are thought to have a direct impact on technology adoption in Norwegian healthcare in general. Since the purpose of this study is to understand how this particular technology is adopted in Norwegian healthcare, factors which might have a direct impact on technology adoption in Norwegian healthcare in general are controlled for. These include general funding other than the funding specifically to this project, scientific environment, R&D level and expenditure in the country, healthcare policy reforming, etc. Such factors do have an impact on technology adoption in general. The theoretical framework is presented in Figure 3.

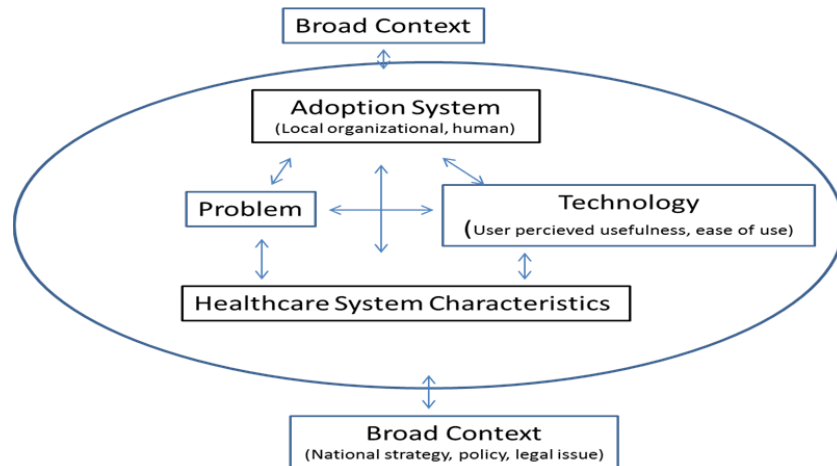


Figure 3.

3. Methodology

3.1 Research Design

3.1.1 Research Paradigm

The interpretivism is taken as the main research paradigm in this study. This philosophical basis is popularly used in ethnography and other social science. Interpretivists believe that the reality is relative and multiple. These multiple meanings are very difficult to interpret as they depend on other systems and context. The knowledge generated from this discipline is perceived through socially constructed and subjective interpretations (Carson et al., 2001, Hudson and Ozanne, 1988). Interpretative study is not reporting “facts”, but based on “thick description” to make interpretations of other people’s interpretations. Interpretative study is not aiming at producing “truth”, but still generalizable findings. This research paradigm is used in three ways in this study: 1) as an initial guide to design and data collection-build on the previous knowledge; 2) as part of an iterative process of data collection and analysis-initial theories being expanded, revised or abandoned; 3) as a final product of the research. Interview is the main source of data for this type of research. The investigator tries to be objective and unbiased. The researcher’s rich prior experience and knowledge in biomedicine/biotechnology is valuable for gaining an in-depth interpretation during the study.

The positivism philosophy is also applied in the study pertaining to evaluation of the technological issues and identification of the successful factors and barriers in the

progression of the technology adoption. The positivist believes there is a single, external and objective reality to the research question regardless of the researcher's belief (Carson et al. 2001, Hudson and Ozanne 1988), therefore researchers are detached observers and they make generalization and abstraction by using rational and logical approach through obtaining hard secure objective knowledge.

3.1.2 Research Method

Qualitative research method is appropriate when one is trying to answer “how” and “why” questions in-depth (Yin, 2008). This is a study about a contemporary, on-going project in its real-life context and is designed as a descriptive and exploratory single qualitative case study, where we provide an understanding of the situation as complete as possible through in-depth longitudinal description of the circumstances under evaluation, the characteristics of the people involved in it, the nature of the community and cultural norms/values in which it is embedded. With this holistic understanding, the interplay of the variables is examined. This study intends to use a combination of deductive and inductive logic to answer the question how an innovative technology can be adopted by Norwegian healthcare system.

An embedded-case study containing several analysis sub-units is planned by analyzing the qualitative data collected from documents, meetings and semi-structured in-depth interviews with executives from all stakeholder organizations. The analysis sub-units include individuals, organizations and inter-organizations. Relevant variables defined in the literature review part will be analyzed at individual level, organization level and inter-organization level. In this manner, we gain deep understanding how the whole Norwegian healthcare system is prepared for adoption and diffusion of this innovative technology, how the innovation are reinvented to match Norwegian healthcare system in practice; and we identify some missing links inside or inter-organizations for a more efficient adoption. This in-depth study may provide information basis about the ongoing activities for managers and decision-makers to identify both present and missing success factors for further managerial actions. Case study protocol and case study database are included in the appendix.

Through a literature review, the initial framework is formulated. This framework provides guidelines for the choice of research method, designing research protocol and

data analyzing. The framework is revised and validated based on the existing theory and results from the case study. This iterative research design is illustrated in the following figure 4.

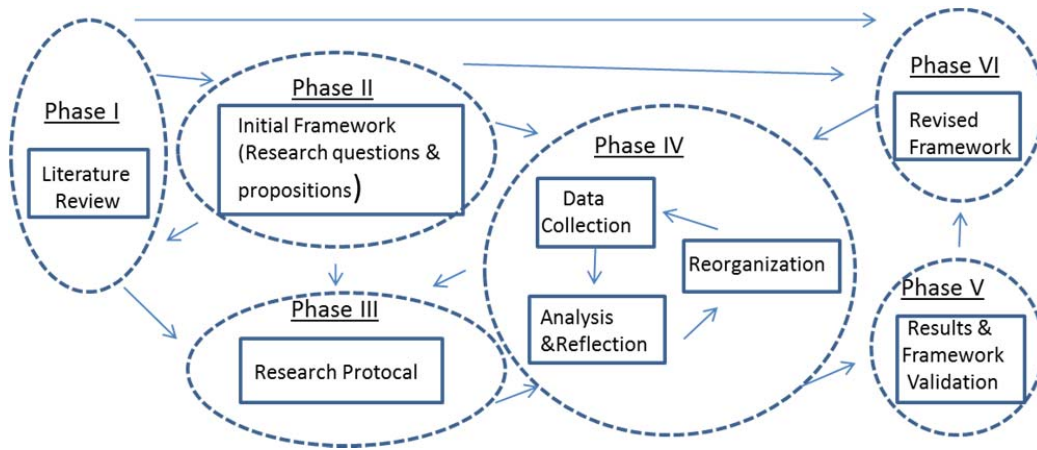


Figure 4.

3.2 Selection of Participants and Data Collection

All the key entities involving in the adoption of PCM as listed in the table 1 are the analysis units and thus participants in the study. The key executives or managers of these entities are the informants initially recruited in the interviews. The snowball technique was used for recruiting additional relevant informants. A total number of eleven key executives representing all stakeholders in the case are selected for interviews. We gained generally good access to the informants with some difficulty to only one organization. This may indirectly reflect the degree of stakeholder involvement in the current stage of technology adoption- the higher involvement, the easier access. In addition to conducting interviews, primary data is also collected through attending meetings/debates and correspondence with a focus group representing clinicians, patients and managers in hospital and governmental regulatory agency. In the situation where there is no interviewee available in the entity, we attended meetings for gaining the primary data. This sampling regime allows us to gather in-depth contextual information both inside- and inter-organization about the progress of technology adoption. This triangular information will build up multiple chain of evidence towards the fact, which will reduce bias and enhance the validity and reliability of the evidence.

By employing semi-structured interview method, we are open to all-round perspectives from all the stakeholders, while staying focused on the topic. Interpretivist investigator enters the field with some sort of prior insight about the research topic but assumes that this is insufficient in developing a fixed research design due to complex, multiple and unpredictable nature of what is perceived as reality. During the data collection stage, the investigator and the informants are interdependent and mutually interactive with each other and construct a collaborative account of perceived reality. The investigator remains open to new ideas throughout the study and let it develop with the help of his informants. The use of such an emergent approach is also consistent with the interpretivist belief of human's ability to adapt and no one can gain prior knowledge of time and context bound social realities (Hudson and Ozanne 1988). These interviews server as our primary data source for analysis, from which we have possibility to obtain both holistic and detailed organization-, process- and event-based information about the project.

Before interview, our interviewees are well informed about the purpose of this study and the questions we shall focus on. A good rapport was generally established between investigator and informants beforehand. The informants talked about topics related to PCM adoption, how they perceive the value of the technology, milestones and challenges pertaining to their roles in the project. The interviewees were interviewed for about one to two hours. The interview was audio-recorded with permission from interviewees for further analysis, while investigator is taking note. Anonymity is ensured. The interview questions are listed in the Appendix.

Some informants are unfortunately not available for a personal interview. The specific information related to PCM was collected through attending meetings and email correspondence. Overview of primary data collection was set up as Table 1. The number of informants includes the total number where the primary data was collected both from PCM meeting and interviews. Some interviewees have several positions in different organizations.

Organization	Number of Informants	Position of Informants	Focus Group with Interviews
Nasjonalsatsingsgroup (NSG)	3	Group member and coordinator	3
Norwegian Cancer Society	1	Department leader	1
Norwegian Biotechnology Advisory Board	1	Senior Secretary	1
Oslo Cancer Cluster	2	Senior Advisor	1
Norwegian Medical Association	1	Executive	
Cancer registration	1	Head	1
Radium Hospital	5	Oncologist, Pathologist, Biologist & Executives	5
Industry Partner	2	Executive	1
Sum	17		11

Table 1.

Secondary data is gathered from archival records, academic journals, scientific meetings, strategy documents, annual reports, government reports, meeting memoranda, survey data and various websites (association, pharma and technology companies), which can be used as information for cross check and conformation during analysis.

All the information from multiple sources was used to corroborate each other. Case study protocol and case study database are shown in appendix.

3.3 Data Analysis

The data analysis strategy was designed in accordance with the research question, review of the literature, and propositions proposed in this study. Qualitative data from interviews will normally generate large set of data. The redundant data was firstly reduced and primary pattern match and time series analysis techniques were used for data analysis.

Pattern matching analysis. Each interview will be firstly transcribed verbatim. Each transcript will be read several times in order to ensure a thorough understanding of the content. The transcripts were initially open-coded based on the independent variables proposed as in the literature review. After an open-coding analysis, the coded information is related and cross-linked to each other, which resulted in a hierarchical cluster coding structure based on the research boundaries predefined as in the literature review. After coding and systematization of the information, the categorized codes appearing in our predefined boundaries are taking into further analysis; the categories appearing most frequently in the transcripts, however not falling into our predefined boundaries, serve as keywords in another round of literature research for identifying their relevance to the project. The analysis sub-units include individuals (scientist, physician, project manager, policymaker and patient), organizations (governmental agency, hospital, pharm industry

and) and inter-organizations (communication and collaboration). Relevant variables defined in the literature review part will be analyzed at individual level, organization level and inter-organization level for stakeholders.

A time series analysis has been conducted to reveal how critical event driving the process forward and how important factors from the pattern matching technique evolve in time. This analysis allows us to trace the changes over time through following the course of events in order to reflect the research question and the theoretical groundings. This analysis can also increase the validity (Yin, 2008).

3.4 Validity and Reliability

When participating in your own research, the researcher could be subconsciously subjective. Therefore from a case study perspective, it is important to establish a plan/tactic for ensuring validity and reliability of the research (Yin, 2008). Based upon the framework defined by Yin regarding to ensuring validity and reliability, the following actions during each phase of this study were taken in order to ensure better validity and reliability:

- Phase of research design: The interviews were designed under the consideration of both internal (content) and external (construct) validity. All the interviews begin and end with the same questions. A design of 360 degree interviewee around the case provides multiple sources of evidence and serves as a good basis for validity and reliability. The use of focus group provides a possibility for an additional clarification on the question as needed. The supervisor has reviewed research design and a case study protocol is established.
- Phase of data collection: The same interview procedure is followed for all the interviews and same questions were asked to different interviewees/stakeholders when it is fitting. The answers were compared to each other and to documents. If the answers are not within the same line, the additional information is sought for further analysis and confirmation. Therefore, multiple sources of evidence and chain of evidence are established.
- Phase of data analysis: Interview recorders and transcripts were listen/read through several times to ensure a complete understanding of the content. A

database containing clean primary data was created for an easy use of complete data. Some analysis method such as patterns matching, explanation building and time series analysis will enhance the internal validity. The patterns were identified through above mentioned analysis.

- Phase of composition: The key informants and supervisor have reviewed the manuscripts to ensure better construct validity. This triangulation of evidence can enhance the validity and reliability.

4. Results

The findings based on the primary and secondary data are presented with a structure of time-series analysis. We have divided the process of PCM adoption into three stages: decision-making, technology acquisition/development, and rollout to cross the chasm. In each stage, the main events and critical factors based on the theoretic groundings are described and narratively analyzed. This analysis allows us to trace the changes over time for the purpose of reflecting the research question and the theoretical groundings. Each of the following sections describes the findings related to each phase of technology adoption and a general pattern is matched to the theories based on the analysis according to the theoretical framework presented in Figure 3.

4.1 Decision-making for PCM Technology Adoption

Personalized medicine (PM) represents the trend for more précised personal medical care. This section describes how PCM adoption is discovered as an opportunity and set as a national priority to be exploited under the stimulation of both exogenous and endogenous factors.

4.1.1 The Initiative from Entrepreneur-Oriented Researchers

The earliest national initiative for PCM was made by a five-person group in 2011. The group consisting scientists and clinicians from the four health regions of Norway submitted a proposal to the health department, suggesting “National priority cancer: Individualized cancer treatment for all Norwegian patients based on the gene profile of their own tumor” (Roy Bremnes, et al 2011). In this proposal, a strategy for building up a national coordinated research and translational platform to provide a targeted cancer

treatment using molecular tumor diagnosis is proposed. This proposal was given priority by the Norwegian Research Council (NRC). The leader of this writing group is leading the “Nasjonalsatsgruppe (NSG) for kreft” responsible for the strategic planning and professional advising, at same time creating a framework for all the stakeholders. In response to this proposal, NRC set out a financial scheme and called for proposals for PCM. A PCM project was granted in 2012 to the national collaboration group for health research-Norwegian Cancer Genomics Consortium (NCGC), and a leader from NCGC was assigned for the PCM program. The NSG group members were included as key investigators for the PCM technology adoption and the practical implementation of the strategy.

The members of this writing group have strong background not only in basic research and clinic, but also in translational research, innovation and technology. Some of them held several patents and were in the process of commercialization of their technologies. These experiences made them particularly aware of the novel technology in industry and market. According to the writing group, “The rationale behind the first initiative is two-fold. Firstly, the knowledge accumulated about the mutations in tumorigenesis and drugs specifically targeting those mutations. There are good cases where a drug works for different cancers and the same mutation involved. Various kinds of sequencing technologies have been improved and a more feasible price is gradually achieved for clinical use. The technology has been used in many prestigious hospital and institutions across the world. We cannot simply wait for its automatic happening in Norway. We have to take actions to make it happen, otherwise it will never happen. Secondly, we have a group of scientists whose scientific level is recognized at high international level. We have a good healthcare system to follow every cancer patient from diagnosis to the whole treatment. We have collected a large size of samples, for example in lymphoma. How should we organize these resources and expertise to deliver a better healthcare and to lift our research level? Focusing on the molecular level for cancer patient care is one field that we have particular strength and resources, and thus a promising way to develop. Although from the historical data we have not yet seen a magic bullet yet for cancer treatment, whether PCM might be the magic bullet, we have to try out. We are always looking for new technology.”

These visionary researchers envisioned PCM as a great opportunity for improving the Norwegian healthcare service. They took initiatives to gather expertise, lobby politicians for financial support. Their actions successfully strengthened the concept of PCM from the national top management. This proposal was systematically evaluated by Health technology assessment (HTA) in terms of resource use, the application of the technology, and a set of technology-related issues including ethics. It is clear that PM will gradually be incorporated into cancer patient management and will have a significant impact on our health care in the future (Diamandis et al., 2010). In compliance to the Norwegian framework, PCM was set as a major movement towards a better personalized cancer care in national strategy and a top-down approach to PCM adoption is initiated.

These scientists proactively take part in the establishment a national platform for a more personalized cancer treatment at an accurate molecular level based on patient's genomic information. The suite of clinical applications of PCM in cancer is broad, "encompassing screening, diagnosis, prognosis, prediction of treatment efficacy, patient follow-up after surgery for early detection of recurrence, and the stratification of patients into cancer subgroup categories, allowing for individualized therapy. By dividing patients into unique cancer subgroups, treatment and follow-up can be tailored for each individual according to disease aggressiveness and the ability to respond to a certain treatment", said an executive in the interview, "This is an advanced technology. To achieve the goal, we need to establish a national platform where the new service can be developed by leveraging our best expertise in academy, clinic and industry."

4.1.2 Governmental Support

Cancer research is set as one of the prioritized field and the patient is the focus. There have been some public funds invested into this priority, including the ones from NRC, Cancer Association and the regional health departments. In 2008, the Oslo Cancer Cluster proposed a concrete solution to a temporary funding for promising cancer treatment-"innovasjonsfond". In early 2012, the NRC launched a new large-scale initiative for biotechnology: Biotechnology for innovation (BIOTEK2021). The estimated budget for the entire program period (2012-2021) is approximately NOK 1.4 billion and the budget for 2012 is approximately NOK 140 million. BIOTEK2021 aims to promote biotechnology researches by funding large-scale, long-term projects that address

wide-ranging societal challenges. This program evolves from the previous national FUGE program, which has invested in NOK 1.6 million over ten years with benefit to a broader-based initiative and played an important role in the creation of new Norwegian companies. Activities under FUGE platform will be followed up and expanded under the new BIOTEK2021 program.

BIOTEK2021 identifies “biotechnology is at the very core of the bioeconomy and a key element in the development of the agricultural, marine, industrial and health sectors” for generating new and improved products, services and processes which contribute to the emerging knowledge-based bioeconomy. A key objective of developing Norway’s fledgling bioeconomy is to maximize sustainable production and processing of renewable biomass for a variety of products. The strategy provides a framework for research initiatives in the interface between social challenges, national competitive advantages and opportunities inherent in biotechnology activities. The complexity and dynamics of the interaction between research, technology and society are increasing rapidly, giving rise to needs for greater knowledge and reflection about the changes we are facing. The BIOTEK2021 program will generate research-based knowledge by applying biotechnology as a basis of understanding life processes, developing policy and generating innovation and industrial development to help to solve major social challenges.

PCM adoption has been funded by a substantial grant from the NRC, under the Program for “publicly initiated clinical cancer studies” and BIOTEK 2021 program for “A national research and innovation platform for personalized cancer medicine” towards 2017.

4.1.3 The Norwegian Approach to the PCM Adoption in Practice

In response to the national strategies including “BIOTEK2021”, scientists have proposed to establish a national platform for personalized cancer medicine by utilizing the core competence in the translational cancer research from both academy and industry. With the funding from research council, the PCM program focuses on better utilization of existing research capacity and results, at the same time takes into account the commercialization of medical products and services. The main mission of this program is two-fold: 1) to analyze molecular characterization of the patient’s tumor, thereby ensuring the patient receives targeted treatment with better outcome and less side-effect;

2) to capture the clinical and genetic data to form a cohort dataset of genetic changes, treatments and outcomes for research and industry. Taking advantage of the knowledge and technology advances, it is possible to make molecular diagnosis as an effective personalized cancer treatment. However, clinical use of PCM is at its infancy with discrepancy from different clinical settings and there is no established ready model that Norwegian healthcare could copy from. Therefore, demonstrating a workable model for delivery of a quality assured effective cancer treatment compliant to Norwegian conditions is a strong motivation for the program.

This PCM program sets out the framework with strong collaboration between universities, hospital research institutions and industry partners. The program is led from the Oslo University Hospital (OUS) and coordinated with the Oslo Cancer Cluster. Principle investigators and clinicians, industry companies have formed a partnership within the program. All the stakeholders and their roles in the program are summarized in the following table 2:

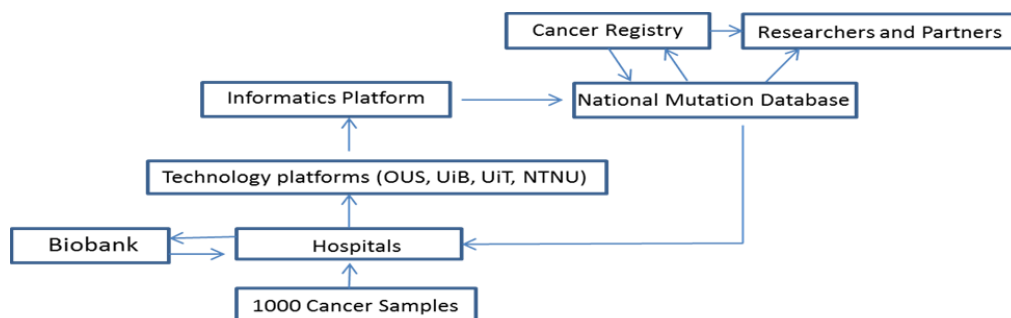
Organization	Role in PCM adoption
Health department	Policy making and monitoring
Nasjonalsatsgroup (NSG)	Strategy and professional advising for PCM, create a national network
Bionemmda	Evaluate social and ethical consequences of biotechnology, give advice to government
Kreftforeningen	Raise funding for research and technology implementation, communicate with public
Research Council	National strategic and funding agency for research & implementation of technology, give advice on research policy for the government
Oslo Cancer Cluster	Facilitate cancer research and clinical use of technology
Legeforeningen	Provide better public health service, health political actor
Cancer Registry	Population-based clinical cancer registration
Biobank	Collection and storage of patient's tumor sample
Hospitals	Technology hub for better research and clinical use of technology
Pubgene	Develop highly integrated informatics platform
Pharm industry partner	Commercialize product and drug discovery

Table 2.

Currently, PCM has been adopted in four national health regions with established sequencing technology platform in OUS/UiO, UiB, NTNU and UiT. Clinical sequence data has been collected through the pilot clinical trials by collaborations between the

clinicians and scientists in the regional sequencing platform. This data will transfer the specific findings for the routine molecular pathology test and to inform clinical decision-making. The genetic data will be registered in the cancer registry and compose a national mutation database for further cancer biology research and drug discovery. Through this process, some main achievable objectives are set:“ 1) to investigate the mutations of known actionable genes across several important cancer types using existing biobanks; 2) to establish sampling procedures and sample logistics, bioinformatics infrastructure, analysis and pipelines, as well as procedures for feedback to the treating centers and the Cancer Registry; 3) to initiate clinical prospective studies based on biological hypotheses including two or more participating centers; 4) the implementation of phase 1 and 2 studies based on the initial findings and current know-how; and 5) educational efforts towards the health service and patients”, according to the program leader.

In practice, the program will sequence 1000 patients in various small clinical trials across the nine cancer types within the first three years. These cancer types are chosen because the higher incidence rates were observed for the Norwegian population and there has been a strong research effort within these cancer types in the country. DNA extraction and analysis will be conducted at the technology platforms in those four universities. Surplus biopsy material will be sent to biobank appropriating further research. Larger series of common cancers and longitudinal studies of few patients (N=1 trial) will be conducted and the outcome data of the personalized treatments and other therapies stratified by mutation profiles will be accumulated over time. The data will inform clinicians with diagnosis, treatment and prognosis. At the same time the information gathered will be valuable for both academy and industry R&D activities. An integrated informatics solution will be developed for capture, storage, access and analysis of the clinical and genetic data. The process can be described by the following flowchart:



After approval of the concept, this model will integrate the lessons learnt from the adoption into a more mature model for reaching the long term goal: implementing in clinics for providing a standardized, cost-effective and routine practice for the cancer treatment in Norwegian healthcare, at the same time lifting the level of Norwegian cancer research using the enriched national mutation database.

With influx of the public fund, a series of milestones were achieved accordingly and they collectively drove the process of PCM adoption. Through a time-line analysis, the major milestones are identified with some possible overlapping in Figure 5. The whole process is delineated into three stages: decision-making, technology acquisition/development and roll out.

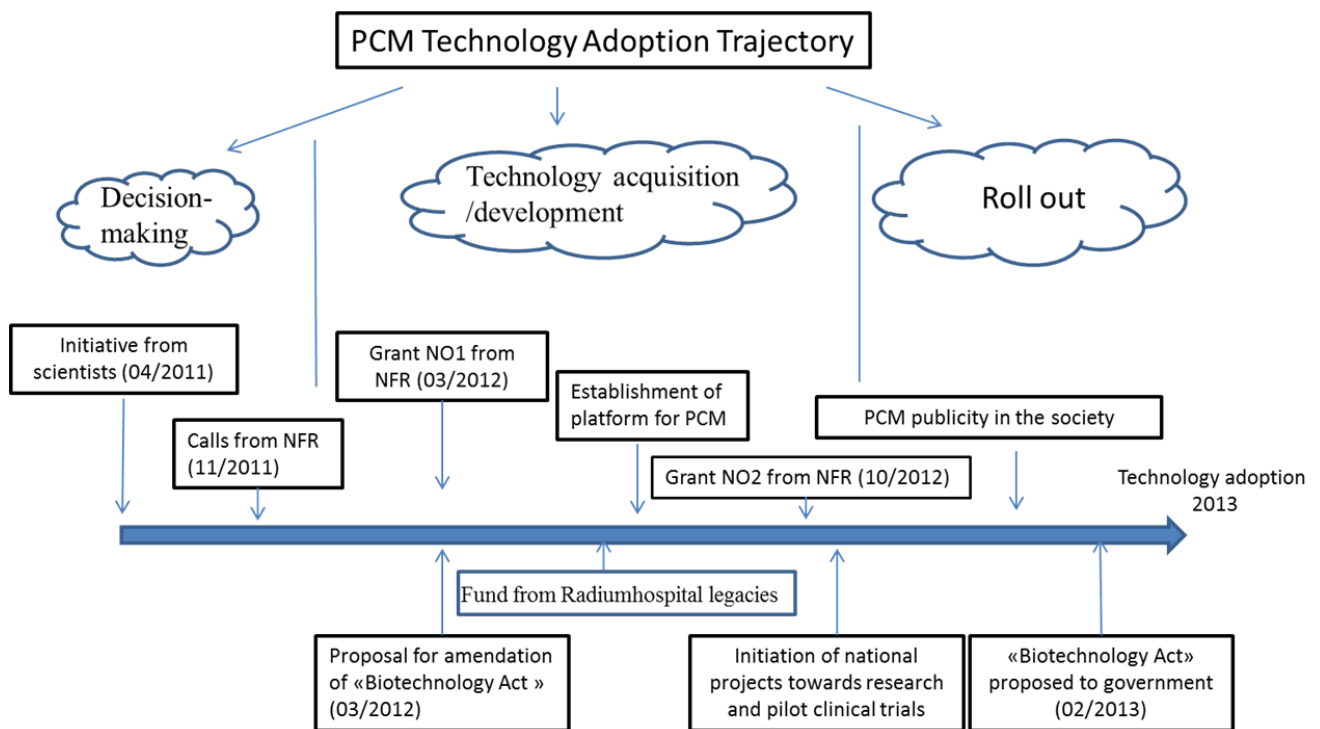


Figure 5.

In this process, a well-articulated solution addressing a public health problem was proposed by visionary scientists and set as national priority for implementation. Government agencies have been important factors in making policies and allocating public funds to facilitate the technology adoption. Tight collaborations between universities, hospital and industry are central for integrating national expertise and

resources to provide this innovative technology for cancer patient. Overall our data supports the proposition:

Proposition1: New technology adoption in Norwegian healthcare is in response to exogenous and endogenous stimulus. The entrepreneurial-oriented researchers perceive the opportunity and proactively initiated the technology adoption. The user perceived usefulness of this technology for resolving an important societal problem stays centrally for the possibility of adoption.

4.2 The PCM Technology Acquisition/Development in Norwegian Healthcare

Since the PCM adoption is set as the national priority, a top-down program-based strategy is applied for establishing a national platform as an actual form of technology adoption. PCM adoption encompasses not just a new service, but also clinical, organizational, regulatory, financial and relational changes involving multiple stakeholders. In this section, we delineate how the critical elements - technology, human and organization within the Norwegian healthcare system, interact or are aligned together, and how they collectively influence PCM technology acquisition and development.

4.2.1 Technology

In the PCM technology adoption, it involves adoption of two different technologies, namely sequencing technology in the lab and an integrated informatics system for data capturing, analysis and interpretation. With the funding scheme from NRC and “BIOTEK 2021”, there was no grant for purchasing machines. An additional grant from “Radiumhospital Legacies” was received for purchase purposes. Currently, a sequencing platform infrastructure is established at the Radium hospital and the machine is running at its maximum capacity. Several clinical trials have been initiated across hospitals.

The technology is chosen according to government guidance combined with local system conditions, it is thus more likely to satisfy the users and organizational needs. The current employed sequencing technology at the Institute for Cancer Research at the Radium hospital, is Hiseq2500 - the newest innovation from Illumina. The Illumina technology has been used in the institute as part of the previous FUGE national platform.

FUGE platform during past 10 years has built up the necessary capacity and competence in DNA sequencing and data analyzing by using Illumina sequencing technology and data capturing system. “Now with the newest Illumina sequencing machine, we are able to work at higher efficiency, accuracy and lower cost. Now running a whole genome exon sequencing for one patient including a pair of tumor and a normal tissue sample takes 25 hours and costs around 18,000 NOK, which is already quite good”, according to an executive. “With the newly established robot assistance, the sequencing efficiency can be further increased. Technology advances dramatically and a relatively high standard technology is important for its long term development. The industry is under constant development for the better technology. We expect it becomes a more economy-friendly technology, especially in the routine use for following-up the patients during the treatment regime. The more patient we include in the trial and the more data collected, the more powerful the technology becomes.”

Currently there are two different technology systems employed nationally within the PCM project. The Illumina technology is chosen in Oslo, Trondheim and Tromsø, while Bergen is using another technology. The different technology represents different detection precision and different sample preparation procedure. Presently, sequence data has been compared and validated across regions with the same technology platform. A standardized procedure for sample preparation and data acquisition will be applied at these regions. However, the data validation between the technologies is not easy due to the different nature of technologies. The issues related to data validation as well as an applicable standardized sequencing protocol across these two technologies warrant further investigation for establishing a PCM national platform.

When it comes to using IT system, each healthcare provider has his/her own agenda. In relation to PCM, the IT usage is a medical/medicine related technology and Clinicians, Oncologist, Pathologist (COP), biologist are the users. Their initial intensions to use this technology are low. These users do not generally possess high IT expertise and often have established their own general knowledge and routines pertaining to the patient diagnosis and treatment. “I have been doing diagnosis in the traditional way for my whole career and it works fine. And now I have problems to listen to an algorithm for diagnosis”, according to a pathologist. In addition to the user intension, the users’

satisfactions are also limited. As stated by a researcher, “the data generated from one whole genome sequencing is at level of GB. To fully analyze such a dataset will take several months’ work for a skilled bioinformatician with a powerful computing machine. Right now, there is no ready, simple software for this analysis. If I opt to analyze this data, I need to learn UNIX and get familiar with all the analysis procedure, starting from data validation and data mining. That is just too much work before one can get some biologically meaningful information out.” For medical professionals, they are much less used to such data mining work, and much more rely on their own knowledge and experiences for diagnosis and treatment. They do not have time to learn complicated IT software. This IT system is hard to learn to use due to lack of a well-developed integrated software and limited technique support.

Regarding to the system quality, this IT system has low compatibility with existing IT system in the healthcare. As a manager said, “We do not have money to establish a secure server with sufficient computing capability, so we are renting computing capacity from USIT where we also get service from. The system is not a part of hospital network and has low compatibility with hospital network. But this is currently the most practical setup for getting it up running, even though the data transferring speed is not optimal. We can even send data there quicker by taxi.” Some researchers carry their dataset around with a two-kilo hard drives and have to buy a new portable PC solely for the data mining process. Users prefer one single IT solution which covers data identification, interoperation, integration and integrity. “It is too complicated, as it is now.” said a user. “This solution should be more user-friendly with a simple interface for data capturing, analyzing and file administration in the clinical settings. For now, the data is stored and analyzed at the University’s net, which is separated from the system where the patients’ electronic medical records (EMR) are kept. Integration of the PCM data with existing EMR is demanded for timely informing doctor’s decision-making. In addition, there is no mechanism for user support concerning PCM data analysis and interpretation. The data analysis is performed at a basis of group collaboration within the hospitals.” There is a need for the development of a better IT solution including a mechanism of user support. In this desired solution, a data warehouse containing timely, accurate, valid and complete data need to be established. Governance of this data across the organization to

ensure efficient resource utilization remains a challenge afterwards. Better user involvement will be helpful to fulfill user needs.

Overall, although the PCM is a complex technology, the technology platform is chosen to be established at an institution where long prior experience and favoring culture for sequencing technology are in place. Therefore the initial sequencing infrastructure was established and up running rather quickly. Contrary to the sequencing platform, a good IT solution for data analysis and interpretation has not yet well developed. The development and adoption of own IT solution appears much slower. A technology specialist as a champion can promote adoption through introducing and developing a technology/product fitting well into users' needs thereby enhancing user's satisfaction. The data above collectively suggested a proposition:

Proposition2: The characteristics of the technology and nature of the problem being addressed will determine the pattern of adoption through a manner of intersecting with a specific adoption system and the broad context.

4.2.2 Human

PCM is a technology applied to the Norwegian specialist healthcare. According to the work flowchart, the people who will be involved in developing and using the technology include mainly clinicians, oncologists, pathologists and biologists. These groups of people are represented in the management team of the PCM program. They are working externally with the government and industry and internally with management of the program.

These leaders work in different institutes as champions advocating PCM technology and are at the center nexus of early technology adoption in various ways. The management team consists of key investigators working in key areas ranging from cancer treatment, cancer research, sequencing technology to development of informatics solution. This profile of management team covers the multi-disciplined fields for development and adoption of PCM. They are either leaders in their working institutions or prestigious scholars in their own fields. They have together as a team envisioned the huge potential and its societal value and streamlined this important message to politicians. Through a close dialog these leaders influenced public policy and secured financing for PCM. This money had been allocated to the technology platform and to the expertise within the field

by the managers of the program. Thus all the resources (finance, human and technology) are well aligned in the same framework. The managers formulated the strategy, dissected it into achievable goals and acted as boundary spanners for practical implementation. All the members in the program work interconnectedly to collectively arrange resources to produce a new service. During this dynamic process, a balanced relationship was achieved through decision making for prioritizing various activities and allocation of finance.

The users of PCM technology mainly consist of three groups of people: clinicians (oncologist/pathologist), researchers (biologist/bioinformaticians) and cancer patient. They value and accept the technology in various ways at different levels according to their stakeholders' role in the technology adoption. Biologists/bioinformaticians possess the core competence for integrating findings from basic research, translational research and drug discovery to deliver an evidence-based solution for clinical use. They have longer experience and thorough understanding about the sequencing technology. They perceive this technology as a powerful tool to understand molecular heterogeneity of tumors and to develop a more precise approach for cancer treatment. "I regard it as a paradigm shift. We need to develop this technology and deliver it to our patient. I hope it could be available in my life," as some researcher mentioned. They are in close contact with other group of users, not only to enlighten the theoretical and practical use of PCM, but also to incorporate the different users' needs and make a better system for Norwegian patients.

Patient interacts with this technology in three ways: as the provider of health-related information; as the receiver of information regarding his/her healthcare condition and the treatment; as the recipient of health-related services and care that utilizes the information stored in the platform. "According to Norwegian law, patients receive good information about their medical conditions by both verbal and paper communication. Normally, there is a good trust and communication between clinician and patients. We have no problem with the information flow from both sides. Namely, patients collaborate well with clinicians, sign the "patient consent" and provide information to doctors without problem", mentioned by both doctors and researchers. "They often accept the new technology for the medication and are willing to participate in the trials for treatment

recommended to be worth trying. So far, oncologists have started some small clinical trials and they have not encountered problems regarding to collect patients' sample for DNA sequencing. When it comes to the national implementation of PCM, I do not perceive a problem from the patient side, as long as PCM is proven to be effective like previous innovation." This was confirmed by a cancer patient, that "We are often under much stress and have been trying all the different available treatments. In another word, we are in a desperate situation. If a doctor recommends a technology/treatment with better efficiency and less side-effect, we have no reasons to ignore it and would rather give it a try. As far as my DNA sequence data, I do not care so much about it. This is me, I am a simple person. But I think there should be a good law rapping up the whole issue." It seems that even though the patients do not possess good knowledge about the new technology, they do have a favoring altitude to the PCM adoption and will participate in the development of this technology under the consultation of their clinicians.

Clinicians are the keys bridging the PCM idea to a practical use. "Clinicians and researchers are in two different worlds. We (clinician) see patients, but they (researchers) do not. I have to pin point one thing is that many researchers emphasize the value of the personalized medical care, but the medical care has been always personalized. We make all the treatments personalized for each unique patient. As a clinician, I definitely favor PCM as it allows a medical care personalized to a more accurate molecular level, instead of an individual level. But I firstly have to see more evidence showing that is working. Now I understand that PCM is a complicated technology and might be powerful. I do not know much about genes. I need more information," said a clinician and an executive in the interview. This statement clearly demonstrates that clinicians are not yet convinced with the usefulness of the PCM over the existing technology. They need more evidence to prove the actual relative advantage of PCM. "We are always looking for new technology. We have a good environment here in the Radium hospital with best expertise in the country and we actively communicate with each other. The only problem is that clinicians and researcher are with different educations and speak two different languages. This diversity is good to create something new, but it is also dividing people into groups. How to bring them together is a challenge. We must find out a good selling point to clinicians and pathologists. But as long as they receive right information, they will take

new technology as a good tool supplementing the existing ones, as seen from previous experience.”

The different groups of people share different perceived usefulness of the PCM, which decides their different attitudes about whether they should start use the technology, at what time point and how to use it. These decisions collectively shape the pathway of technology adoption at the organizational level. For researchers, they are excited about the progress and willing to apply the technology in their research. However, the scope of technology application in research is limited by the limited data accumulated in the PCM platform. The more data collected, the more powerful the tool is, and the higher research level can be reached. So researchers are the main driving forces for the technology adoption. They have the power of knowledge, infrastructures and money to reinforce the development of PCM. They can assure that a reliable, high-quality tool is going to be developed, which is a premise for the PCM adoption. Together, researchers as a stakeholder in PCM adoption have high power, legitimacy and urgency.

Clinicians are busy with patients and they work simultaneously with various choices for cancer treatment. Although they have motivations to look for “a precise, patient-tailored treatment through which the wrong treatment can be avoided and less side-effect can be achieved”, they consider the “current cancer treatment is good for controlling tumor progression, as most cancer types are indeed curable except some big ones. However, the bigger problem is the side-effects associated with the treatment and many patients are dead of that. This is especially the problem for young patients, as they have not really experienced the world.” This shows that the oncologists have some motivations to adopt PCM, but they perceive this not to be an urgent matter. Therefore clinician as a stakeholder in PCM adoption has some power, legitimacy and urgency.

Patients are loyal partners in PCM adoption, although they do not have much power. They strongly wish for a development of new treatments. Therefore patient as a stakeholder in PCM adoption has lower power, legitimacy and high urgency.

The power, legitimacy and urgency will together decide the salience of each stakeholder. The salience of main actors in the technology acquisition/development phase is described as following, which provides the basis for stakeholder managerial actions.

Stakeholder	Power	Legitimacy	Urgency	Saliency
Researcher	High +++	High +++	High +++	High +++
Clinician	High +	High +++	High +	High++
Patient	Low	High +++	High +++	High +

Table 3.

At current stage, researchers in the program represent the highest salience and are the driving-force for the PCM adoption. They have strong motivation, knowledge and resource for technology adoption. They are in close contact with all the stakeholders and can mitigate the risks for each group of actors. Therefore, they act as group of technology champions and in collaboration with leading-edge clinicians and strive to build up a workable model integrating representative of major actors in Norwegian healthcare to demonstrate the efficacy of PCM. A champion as a manager can promote adoption by developing technology accommodating to the country specificity, balancing the relationship of various stakeholders through resource allocating and decision making. This data suggested the following proposition:

Proposition 3: The technology champions as managers advocating an innovative technology are at the center nexus of early technology adoption in the Norwegian healthcare.

4.2.3 Organization

The PCM project is led from OUS and the infrastructure is established at the same institutions where both project leaders and employees have extensive experience with sequencing technology from the previous FUGE project. With this set up, the infrastructure is located at the only national cancer-specialized hospital surrounded by the high profiled cancer researchers, and is managed by experienced national experts. The necessary resources (expertise and infrastructures) for the major targeted users of this PCM technology have been organized in the harbor where innovation for cancer treatment will advance. This organizational setup will in principle shorten the time to PCM adoption in clinical use, as resources are arranged in the best way both horizontally and vertically, which largely reduced the time acquiring the high technological expertise

for doing sequencing analysis. The alignment of the organizational strategy with the up-to-date technology infrastructure facilitates the technology adoption in practice.

Organizational readiness is established in several ways for PCM adoption. For instance, the culture for using the technology in research has been well shaped in the institution. Seminars and research meetings are held on a regular basis pertinent to both clinical and research use of existing and new technology. Informal discussions during lunchtime have built a good rapport and communication between biologists and oncologists and fostered a favorable environment for the innovative solutions to complex clinical problems. This is good for encouraging all the employees to make use of this new technology. In Norway, there is a relatively low hierarchy at workplaces and the teamwork spirit is important. All the employees are respected and treated equally, also in the decision making process. Staff members' participating in the discussion can enhance the familiarity about the technology, hence technology adoption.

Three types of communications were observed in the early PCM adoption: patient-physician, physician-molecular biologist and biologist-biologist. "Cancer patients are the most loyal partners in the course of PCM adoption. They are willing to take new biopsies for a new DNA sequencing test as the oncologists recommend, and sign all the general patient consent without any problems", as an manager described. A generally good interpersonal communication between the patients and the oncologists is apparently established. Meanwhile, several good communication channels between biologists are established through professional networks and meetings. Regular meetings (2 times per year) are held among the principle investigators and the collaborative clinicians. In addition, newsletter, mailing list, sample list and forum on NCGC website are important channels to communicate and coordinate nationally with the professionals. Although there is no special bioinformatics department, there are quite handful bioinformaticians working in the same institute and helping with data analysis. Researchers and clinicians can get consultancy about data analysis using the available technology/software and interface. However, "the consultation may not seem sufficient when researchers or clinicians have to deal with complex and tedious data analysis by themselves with current available resources," said a researcher. The situation can be worse for an oncologist when she/he tries to grasp the essential information for making a diagnosis and prescription, as

oncologists are generally less familiar with genes and their implications, nor with the different computing programs. They feel difficult to get real understanding about the technology, even they have a desire to. The worst situation is between the pathologists and the biologists. “The meeting among pathologists is extremely boring, and pathologists have been invited to our meetings, but they seldom showed up”, said a biologist and executive. As a pathologist mentioned that they are used to the traditional diagnosis and have low motivations to listen to an algorithms’ instruction for diagnosis. A better communication shall focus on establishing a mutual understanding between how the traditional and PCM technology can be good supplement to each other for making a timely and precise diagnosis and prescription for cancer patient. Otherwise, the lack of sufficient communication between physicians and biologists can be a bottleneck for the PCM adoption/implementation.

Several external organizations have collectively worked together to attract more societal and industry attentions to the PCM technology. A number of collaborations and partnerships are formed. Oslo Cancer Cluster (OCC) as one of the “Norwegian Centers of Expertise” is dedicated to accelerate the development of new cancer diagnosis and medicine through collaborative networks, and public policy, among others. OCC brings both academy and industry partners within and outside Norway together to evaluate their interests and to foster the possible engagements. The Norwegian Cancer Society (NCS) has worked extensively through open meetings, debates and free concerts around the whole country. “These events as important educational vehicles have made a good publicity for PCM, cancer research and patient care. NCS raised a good donation for cancer research and clinic applications. NSC has now received gradually more applications from clinicians in response to our application calls. Clinicians are more aware and participating in PCM field.” Connection with the external organizations is helpful for researchers in academy to “get to know the real world and what the real needs are. This has also made our research more useful in the sense of meeting the real world need,” as a researcher said.

Some pharm companies have formed partnership within PCM program. They will contribute to the technology integration for making a standardized and scalable routine within Norwegian healthcare. These industry partners are mostly small Norwegian firms,

where their core competence is supplementary to academic and clinical actors. Although some international large pharm companies have interests in the partnership, they characterize Norwegian pharm investment environment “as small and quite different as the other countries such as in England and Germany”, where the investment environment is more dynamic and mature. In addition, the available small sample size for PCM is limiting the potential interest of investment for pharm companies. Currently, the public funds remain the form of financing source. The possibility for the participation of industry partners in this program is worth further development.

As a tradition in Norwegian healthcare system, the Ullevål hospital has the power for decision-making regarding to diagnosis. In this way, the working efficiency for cancer diagnosis using PCM is largely reduced, as the technology is especially for cancer patient and implemented in cancer-specialized Radium hospital, apart from Ullevål hospital. “So there is a power distribution problem between different hospitals”, said an executive in interview. The Radium hospital is the only cancer specialized hospital within the country and it is an organization pursuing clinic, research and education activities. Most of those oncologists working in the cancer departments in the other regional hospitals are trained in the Radium hospital. The Radium hospital has gathered predominant competent resources in the country and is naturally the trial site for PCM adoption, including clinical decision-making. The experience and lessons learnt from this prove-of-concept phase at the Radium hospital could be integrated into a more mature model for PCM implementation later or in other hospitals.

4.2.4 Fit between Human, Organization and Technology

The fit between these three factors are recognized. The presence of a strong pro-adoption coalition of interests facilitated the both decision-making and actual PCM adoption. The organizational readiness enabled a relatively quick establishment of sequencing platform, thus a quick initial adoption phase. The strong user acceptance from researchers and clinicians laid a foundation for technology uptake, while the difficulty with data analysis, interpretation and limited computing accessibility are the internal limiting factors for technology implementation at a larger scale. The present operational manner in the local adopting system represents a way of creative technology customization in terms to the way and scope PCM works. A better internal fit between

technology and user need could be further achieved through development of a user-friendly highly integrated informatics solution. New skills and competence will be acquired along the process of developing platform. Therefor adoption of individual technology may locally change the shape of the adopting systems themselves by creating precedent, developing new skills and empowering certain groups rather than others. For instance, the previously established FUGE platform has paved way to establishment of the PCM platform at the Radium hospital. The adoption of a given innovation can change the capabilities, interests, values, and power distribution of the adopting system and render it more likely to adopt future innovations.

The fit between the human and organization has been facilitating the adoption process. The entrepreneurial-oriented scientists work in the hospital research institutions and in close contact with hospital clinic entity. This close connectedness creates a favoring information flow for these scientists to comprehend the need for a new technology for cancer treatment. The program-based technology adoption can effectively gather multidiscipline-professionals working in the same framework and promote adoption across the whole healthcare system, while without changing the organizational structures and being able to respond with great flexibility. Under this flexible framework, the program managers have prepared the appropriateness and conditions for good practice, balanced relationship between various stakeholders, and participated in the product development, trial design and drove the process forward. They acted as both managers and champions systematically advocating the technology adoption in accordance to the national strategy.

A good organizational fit across organizations is more difficult to reach and will take long time to obtain. For instance, cancer registration (kreftregisteret) has responsibility to establish a complete population-based cancer clinical database. In the future when PCM is implemented, this data will be more enriched with more molecular markers and mutations. Such database in principle is extremely powerful, for example, for designing clinical trial for testing new drugs. However, in the current system cancer registration is only able to return patients' information to doctors and researchers, when the patient is in Oslo. Due to complicated ethical issues with different level of patient consent, cancer registry is not able to return patients' information to doctors when the

patient is in other region of the country. “This will largely reduce the power of our cancer registry. And we hope a new system can be developed in the next few years. When we talk about a PCM national platform, we need a system with a national standard to be applied nationally”, said the head of cancer registration.

Although the cost-effectiveness cannot be reached in current approach due to the small sample size, PCM can inform decision making for specific patient with molecular characterization for right diagnosis and treatment and at same time avoid unnecessary treatment, which will save both patient’s time and unnecessary cost. Therefore, at this early stage, delivering quality assured service will be the initial net positive benefit, which will continuously improve to become cost-effective along the technology advancing. The other positive net benefits includes that 1) clinicians will gradually acknowledge and adapt to the concept of PCM, therefore providing better health service to the nation, as a clinician said in the interview; and 2) researchers will be able to discover and validate biomarkers as actionable gene for cancer treatment based on Norwegian data; and 3) these data will be returned to contracted industry partners for drug-discovery.

4.2.5 Broad Context

Technology advances have enabled the development of a model of discovery, translation and delivery for personalized treatment. Patient is the most fundamental partnership in PCM adoption, but they have lower power. There are important ethical, legal and social implications regarding the selection, consent and use for patient information both in clinic and further research.

Understanding how to afford trust and to provide adequate support for ethical concerns relating to the handling of sensitive DNA data is a particular challenge for PCM adoption. Genetic code represents personal information. If information about a person's genes is treated as the same way as with other health information - so for example, insurance companies can gain access to them - or should it be regarded as particularly sensitive information? This is an ethical question and everyone has a different opinion from her/his culture background and experience. Ethics is necessary at the moment of moral content is no longer self-evident. It may be because a new event or insight casts doubt on our moral convictions, or it may be that a new issue arises when our morality no

longer has any clear solutions. The latter is often the case for biotechnology issues: these issues are so new that few have clear moral views about them. “Biotechnology Advisory Board has responsibility to create debate and gather information around biotechnology related ethical issues. We collect information about technology, different opinion/values, as well as consequences and risks for what we are doing in our society. PCM technology will produce a huge amount of data. Who owns this data? We give advice to department regarding how to handle this data in a sensible way, what should be known and how to interpret the law in order to take care of the future value of data. We, a working group with representatives from healthcare system, started revising “Norwegian Biotechnology Act” in Dec. 2011 and now the new Biotechnology Act is proposed to the department and hope it will be in action soon.” said a senior secretary in a deep interview.

A reimbursement device with national coverage and emphasis on cost containment, efficiency, and affordability will facilitate the PCM adoption and implementation after its demonstrated therapeutic benefit and cost-effectiveness.

Proposition4: The alignment of stakeholders’ perceived benefit in a broad context will influence the trajectory of technology adoption.

4.3 Roll Out-Cross the Chasm

PCM is hitherto adopted in Oslo with established infrastructure and some small clinical trials running by small number of key investigators, which demonstrated a good trialability of the concept and the technology. According to Moore, these key investigators are characterized as early adopters and are the technology enthusiasts and visionaries. They possess great desire to explore the technology and have extraordinary influence in organizations. In the process of PCM adoption, these early adopters are the program managers, who actively work as champion on advocating the use of the technology. Making the transition between visionaries (early adopters) and pragmatists (early majority) is the most difficult step and is the chasm that Moore refers to. As the program advancing, the need of preparing for crossing the chasm has become more salient. Visionaries and pragmatists have very different expectations. To successfully cross the "chasm," managers should explore those differences and use some techniques. In the case of PCM, the key managers are visionaries and the rest oncologists, pharmacists and researchers belong to the main stream pragmatists. The main difference

in mindset and behavior between these two groups includes user's perceived usefulness, understanding and intention to use the technology.

The managers recognize this difference very well and have set out a series of activities on promoting clinician's cognitive acceptance of PCM. These clinicians as pragmatists have insufficient knowledge of genetics and genomics and are waiting for more evidence before making their own choice. The program managers have set up a wide range of multi-discipline seminars combining the theory and practical application of the technology at different levels. Several external organizations (Oslo cancer cluster, Kreftforeningen) have also together built up a platform for discussions. Clinicians are thus able to receive relevant information directly from various vehicles. Those successful cases led by peer oncologists have clearly shown how an oncologist could use the technology and benefit from it, thus have been an influential education for oncologist. According to kreftforeningen, they receive gradually more grant applications from oncologists. This indicates that more oncologists get to understand the power of the technology and would like to proactively seek opportunities for using it. Once some clinicians are educated and get more good experience, they will gradually become ambassadors for the marketing the technology to the next group. In this way, current clinicians will progressively receive better knowledge about PCM and get more involved in technology uptake. In addition to oncologist, genomic consultant is responsible for patient consultation regarding to interpretation of genomic data. There are currently only 30 genomic practitioners in the country, according to legeföreningen. This seems an insufficient number when PCM is implemented nationally. Therefore a long term strategy should include more investment in biomedicine education in medical schools to educate more such specialized professionals.

The ease use of technology is a factor influencing the technology acceptance. A continuous endeavor for delivering a user satisfactory technology is observed both for the sequencing and IT solution within the available resources. During this process, users are closely involved and some developers are the users, thus the users' needs can be grasped and reflected. It is still wise to remain alerted to those technology advances and drivers in the market, thus a technology better fitting to user's need could be integrated through f.e. strategic alliance. Currently, industry partners are hesitating to invest due to "the bad

images of Norwegian biotech compared to the international pharma environment, such as in England and Germany”. Norwegian scientists, on the other side, point out that “the country should use our limited public funding to develop our own competency instead of financing international pharm industry. We could have collaboration with industry on some era, but not within the core of the business.”

There is a requirement for an entrepreneur-orientated thinking for recognizing our strength and weakness in the core of the business, and be clear with the field where we need and could partner with others. This strategic analysis would guide a creative approach towards a win-win partnership with industry partners. To date, designing a highly integrated IT solution that better meets users’ needs could be a field where industry collaboration *per se* as welcome, for example.

This program has been financed through public funding. In this top-down strategy, a continuous funding will be more secure when a clinical utility can be demonstrated to the stakeholder such as clinicians and payers. At this stage, exemplar showcases have given the impression how the technology is working. Forming a standard test protocol in guidelines will be essential for technology implementation nationwide, as well as for determining pricing and appropriate reimbursement for PCM. This information would be indispensable for establishing a complete business model for providing this service.

4.4 Facilitators and Barriers

Based on the theoretical grounding, this empirical research revealed the facilitators and barriers for PCM adoption in the Norwegian healthcare system as in table 4.

	Facilitators	Barriers
Technology	User perceived usefulness, user involvement and interaction, Tialability, obsoervability	Complexity, insufficient end-user support, cost, incompatibility, limited sample size
Organizational	Single healthcare system, professional communication vehicles, tight collaboration between researcher and clinician	Limited organizational fit across organizations, limited industry collaboration
Human and Social	Champion and leadership, dynamic clinician-patient relationship, learning capacity, peer influence	Cognitive boundary for clinician, oncologist and pathologist
External	Government support, public finance, trend of technology development, good collaboration with relevant external organizations, biotechnology act in place	Lack of reimbursement mechanism

Table 4.

5. Discussion and Conclusions

Healthcare organizations face tremendous pressure to continuously provide high quality health service with well controlled expenditure in most countries. Prior experience in many industry sectors demonstrated that disruptive innovation is the most powerful force to meet the need of “cheaper, simpler, more convenient product or service that starts by meeting the needs of less demanding customers” (Christensen et al., 2000). There are two mainstreams of technology innovation in healthcare system: technology towards high end for specialist use to cure the complex diseases by simplifying complex problem; and technology towards the low end for patients use and thereby relieving the general practitioners and professionals, so they can be better focus on the more difficult problems (Christensen et al., 2000). PCM fits into the first trend. However, healthcare is a change-averse industry with inherited barriers for innovations. These barriers within economic, organizational and behavioral dimensions will impose challenges at various degrees for innovation uptake when a disruptive change provides an opportunity for new entrants or ideas to challenging existing stakeholders within a specific healthcare system (Phillips and Garman, 2006). The resistance from existing stakeholders will be manifested in a unique technology adoption pathway in a specific healthcare system, which intersects with external and internal factors and the nature of involved technology then results in distinct adoption trajectories.

The Norwegian healthcare system is often described as a decentralized national health service with universal coverage. Regional health authorities oversee all hospitals in their region, and are led by an executive board, appointed by the Minister of Health. The most important regulatory mechanisms for the healthcare system in Norway are thus the government providing finance, presenting aims and working plans to the hospitals, and the municipalities with similar responsibility for local primary care (Morland et al., 2010). The Directorate for Health is responsible for National Clinical Guidelines, while Medicine Agency is responsible for regulating and reimbursing drugs for primary care. The health technology assessment (HAT) has responsibility to systematically evaluate the medical, economic, social and ethical implications for the introduction of new technologies in healthcare (Morland et al., 2010). National Council set national priority and quality improvement in healthcare. Council selects topics brought forward by

members and can recommend solution, after thorough evidence-based assessment, to Directorate for Health for resolving a critical problem in health (Morland et al., 2010). This healthcare structure sets a stage for a top-down strategy as a feasible technology adoption approach. At the same time, it underlines the possibility for proactive actions from different “levels” of healthcare sectors.

The first proposition draws attention to the importance of alignment between external environment and the internal need for adopting a new technology in the process of opportunity discovery. The researchers and clinicians discovered the opportunity through identifying new internal desires and new area of value, searching external environment and matching external factors to the internal needs. Consequently, the opportunity was recognized as national priority and the “agency” was brought to exploit the opportunity. The case of PCM represents an exemplar model on how a top-down strategy could be an effective mechanism for technology adoption for a high end use, when combining the bottom-up information. In this strategy, Norwegian healthcare organizations leverage the resources and take advantage of the benefit of intrapreneurship through encouraging initiative, identifying opportunity, establishing technology champion, developing appropriate collaborations and alliance to exploiting the opportunity, which are the critical components for a successful innovative technology adoption in the Norwegian decentralized healthcare system.

The group of researchers and clinicians together as a team discovered the opportunity under a context of risk as it is currently unknown what the feasible model for PCM adoption and implementation is. An appropriate model can be only synthesized after experimenting. Scientists and clinicians can be regarded as entrepreneurs, who use imagination and judgment to interpret economic data and anticipate market conditions to actively formulate and solve new problems (Alvarez and Barney, 2007). According to Kirzner, these researchers and clinicians are “alert” people and aware of opportunities created by exogenous shocks-technology advances. They are more proactive and associated with more information accessibility and have cognition towards innovation (Kirzner, 1999). The scientists and clinicians have recognized the problem with cancer patient that underlines the need for a more accurate molecular diagnosis and prognosis technology. They made a comprehensive judgment grounded on the cancer research and

genome analysis from recent technology advances and then creatively proposed that the PCM could be an idea solution to be exploited. The knowledge accumulation in cancer research and sequencing technology advances are the exogenous impetus for clinical use of PCM. During this process, the group has collected opinions from the key stakeholders and collectively exercised their subjectivism judgment to recognize the opportunity and subsequently took a proactive action for gathering resources and necessary support. Subsequently, their proactive lobbying has made a good publicity among the governmental decision-makers and the governmental funds were granted.

Prior to technology adoption, a national advising group has set up the guidelines regarding to the visions, scientific basis, and how to gather competence to exploit the opportunity and reach the goal. According to this strategy, the opportunity is exploited within healthcare system as a national program in a manner of tightly collaborating with academic research institutions, universities, hospitals and Norwegian industry with an aim to provide a new and more accurate diagnosis for cancer patient at specialist care entity. This collaboration brings together the best competence in multi-discipline field including all the stakeholders to carry out the mission with reasonable public funds. This partnership allows the exercising of entrepreneurship without an actual enterprise. Such program can be regarded as an inter-entrepreneurial activity within healthcare system for an improved service through adaptation of an innovative technology (Christensen et al., 2000). This strategy fertilizes entrepreneurial activity in our healthcare system in a cost effective manner.

The mission of Norwegian healthcare and university hospitals is firmly rooted in the service, education and research for patient care. The resource is controlled with a governmental and societal consensus towards this mission. Therefore the role and responsibility of healthcare organizations and their employees are subject to myriad regulations, professional and historical factors, which will encumber changes to the hierarchical system and participants (Phillips and Garman, 2006, Morland et al., 2010). The Norwegian healthcare is founded by public funds and limited private donations. This non-profit healthcare operates differently from for-profit ones. This very nature is in conflict with the environment favoring entrepreneurship, where the primary emphasis is exploiting opportunity for individual achievement and rewards. However, the healthcare

has a need for better performance with high efficiency and quality service. The better performance can be achieved through an internal test within a relatively high hierarchical organization - namely intrapreneurship. Often a public fund is put up as risky money for exploitation of new ideas and researches within health care, such as the American NIH fund. The NRC provides such a resource for national priority within the health. Within the project, the new method and the new model of service can be created and tested for its feasibility. The mission of intrapreneurship is a better performance of the organization resulting from a group of employees, rather than personal achievements.

The second proposition points out the characteristics of the technology are the core which interacts with its soft periphery and together determines the adoption pattern. PCM technology can be roughly described as a combination of sequencing technology and Highly Integrated Informatics Platform (HIIP). Facilitating the acceptance for both technologies is necessary for the PCM adoption. At the organizational level, the process for the PCM adoption can be conceptually delineated into several distinct phases, ranging from technology assessments to actual technology acquisition and implementation. Often these phases are concurrent and overlapping. The practical realization of the PCM adoption is led from OUS with key investigators from different working places in the field. The advantage of this structure is that the technology platform can be established at the suitable institutions, where organizational, cultural and human resources fit best to its functions, thus largely reduces sunk cost for operation. For example, the sequence technology platform is established at the previous FUGE sequencing platform and essentially the same technology is employed for PCM. The staff has already gained extensive experiences with the technology and this technology has been well accepted within research environment when the PCM starts. These are the major reasons this specific technology is chosen -the good fit among human, technology and organization. Therefore, the phase of technology assessment is shortened and processes quickly run into the technology acquisition and implementation. Comparing to the sequencing technology, the adoption of HIIP is following more typical phases. Currently, a mature HIIP efficiently addressing users' needs for the PCM has not yet adopted. A Norwegian industry partner is responsible for the development of this HIIP integrating oncology, genomic research and pharmaceutical advances for the cancer treatment. Furthermore, the

decision support tools including electric medical records will be needed for data interpretation and point-of-care decision making. Development of such a HIIP will go iteratively from assessment to acquisition and implementation for several cycles.

Linking to the literature, Technology Acceptance Model (TAM) suggested that user perceived usefulness and ease of use are the decisive factors for users' actual attitude to accept a technology. External factors embedded in environment and organization are jointly influencing users' attitude (Davis et al., 1989). The better fit among technology, human and organization factors will lead to better acceptance of a HIIP, therefore the willingness to use technology (Yusof et al., 2008, Yusof et al., 2007).

The end users of the PCM include clinicians, oncologist, pathologists (COP) and molecular biologists. Our study shows that except the molecular biologists, the rest group of users has very limited knowledge and experiences about the gene and the bioinformatics. The COP users generally perceive the PCM positively for the future patient care and are open to the PCM adoption, despite with recognized conceptual and practical challenges. Currently, the group of COP lacks evidence-based clinical information for the actual technology acceptance. This is in consistent with the previous survey from US and Canada (Bonter et al., 2011) where lack of education and evidence-based information is one of the major barriers for PCM adoption. To lift their interest and level of understanding is critical for the PCM acceptance, as these groups of users will participate in the diagnosis and make treatment plan. Previous research showed that attitude of key personnel is an important factor in technology adoption in an organization (Yarbrough and Smith, 2007). Proactive cultivation and management along time could reinforce a favoring environment and lead to the technology acceptance. Professional seminars and workshops with successful showcases are effective vehicles for facilitating communications about the technology and its application. The peer can largely influence the attitude towards a PCM technology adoption (Ginsburg and McCarthy, 2001, Bonter et al., 2011). The key investigators in the program have been actively working for promoting user-perceived usefulness from technology acquisition and implementation to software development, from managing the project to educating clinicians.

Perceived ease of use (PEOU) is regarded as important factor for the choice of technology adoption (Davis et al., 1989). PEOU was inversely correlated with the

adoption, especially at the early assessment phase. In advanced adoption phases, PEOU does not appear as important as in the preliminary assessment phases. Technology appraisal may be considered increasingly manageable over time by trial use and end-user training, which would produce scientific evidences and justifications necessary for the underpinning the essential technical knowledge. In our study, DNA sequencing and PCM are perceived as complex technologies, especially for the COPs who are unfamiliar with the context. They are unable to use it by themselves. In collaboration with biologists, some oncologists in the program have started small clinical trials within the certain cancer types. Along the trial, these oncologists get better understanding of the technology and communicate to other clinicians through seminars. Effects of trial use and training are thus enhanced with adequate communication to individual physicians.

The proposition 3 links to the role of the technology champions in the process. The PCM program is managed by a group of key investigators consisting of biologists, clinicians and oncologists. At the same time they are recognized as technology champions advocating and customizing the technology in the early stage. Therefore they have important functions from management to technology development and adoption. According to the stakeholder theory, managers have a unique position at the center of the nexus of contracts, namely they are the only group of stakeholders who enter into the contractual relationships with all the other stakeholders and who also directly control the decision-making apparatus. Managers' values and perceptions are vital for identifying the stakeholder salience and deciding which stakeholder should receive managerial attention. They collectively make strategic decisions and allocate resources in a manner of most consistent with the main stakeholders along the dynamic process. At the same time, these key investigators are the early adopters characterized as the educated community leaders. They build and test out the model to provide new services through adoption of the technology. According to Everett Rogers (2008), the most difficult gap for technology adoption is the adoption from early adopter to majority. The majority group is more conservative but open to new ideas. They are active in the community and have peer influences. When an individual considers adopting a new technology, the process goes through a sequential stage of awareness, interest, evaluation, trial and adoption. Hence, the early adopters-the technology champions should deliver the right information to the

possible majority adopters, cultivate the interest through trials and lead to final adoption. The public meetings and debate widely organized in the society by other organizations such as cancer registration and Oslo Cancer Cluster have aroused huge publicity for the PCM, which will together foster an environment for the PCM adoption. This whole process will create a bandwagon effect for a majority adoption in the organization.

The literature suggests that the innovation adoption and diffusion process may take a variety of different forms, as every adoption process is driven by various interconnected rational, institutional, and political forces within organizations. These factors interact with each other and with innovation over time to produce particular patterns of adoption (Rogers, 2003, Rye 2007). This single case is representative of technology adoption in the Norwegian healthcare system. It is involving multi-discipline collaborations and actions from the health department, hospitals in all the health regions to the industry partners. The issues in the aggregates of the case represent the theory of technology adoption in healthcare. This empirical study has demonstrated some special aspects for high-end use technology adoption in Norwegian healthcare system, which can be generalized to the theory.

Entrepreneurial orientation that generally includes three dimensions: innovativeness, risk-taking and proactiveness, is described as “the process, practices and decision-making activities that lead to new entry” (Lumpkin and Dess, 1996). New product may lead to firm’s better performance, thus firms may benefit from adopting an EO (Rauch et al., 2009). On the other hand, firms pursuing higher EO are faced the downside of the decision involving risk-taking and allocation of scarce resources, which strongly calls for evidence-based strategic management. In this top-down strategy, it is clear that government policy governs innovation adoption and knowledge utilization by focusing attentions and resources on certain priorities (Dopson et al. 2002). The strategic positioning and significance of innovation set by the national priority catalyzes technology adoption and functions as a control for risky initiatives. The scientists with higher EO have a clear role in participating in formulating creative strategy for decision-making and technology leadership. They are at higher position, with greater tenure and greater experience, which could mean legitimacy and knowledge for navigating political waters, and thus, could be positively associated with adoption. Denis et al. (Denis, 2002)

emphasized the importance of the interests, values, and power distribution of the adopting system on the ultimate adoption of innovation. In this case, a combination of top-down and bottom-up strategy has allowed applicable, evidence-based technology to be prioritized for a feasible adoption. In the situation where only either top-down or bottom-up strategy applied, it can lead to poor applicability after adoption (Ole Frithjof Norheim, 2001) or fail to raise interests for the adoption for mature technologies with rich scientific evidences (Lemieux-Charles, 2006).

The organizational culture is the context in which EO activities occur (Wales et al., 2011). Local conditions have influences in terms of technology choice, available technology expertise and organizational structure. A technology which requires minimum change will be the best choice for gathering technology expertise and will suit and function best in the current organizational structure. Organizational attributes have been the most examined category of the technology adoption researches. Organizational process influences individual, team-based and organizational learning. The sustained entrepreneurial productivity requires internally knowledgeable team entrepreneurship and an organizational environment (including effective governance) that encourages cognitive heterogeneity, positive team dynamics and resource learning (Foss et al., 2008). The greater professionalism, specialization, internal communication and complexity are positively associated with innovative behavior. The innovative behavior typically depends on the combination of (1) which organizational actors (and in which combination of consensus and conflict) are differentially involved, and hold change values; (2) the type of organization in which such combinations of involvement, attitudes, and values take place; and (3) the type of innovations that are being researched (Rye and Kimberly, 2007). These combinations within the organizations influence the decision-making activity, thus the adoption. In the case of the PCM, improvement of cancer treatment is the common goal for both clinical and research entities in the whole Radium hospital. The cognitive heterogeneity between clinician and researcher will facilitate the generation of new ideas, but may impose challenges for the technology adoption, under the situation when this specific technology challenges the value of a specific routine of certain group of people.

Previous researches demonstrate that an entrepreneurial style *per se* is not necessarily desirable in all situations. The positive (or negative) influence of an entrepreneurial style on organizational performance is defined by certain internal and external characteristics. Organizational performance will be enhanced when there is a good “fit” between management style and various contextual factors (Dalton et al., 1980). An entrepreneurial top management style has a positive effect on the performance of organically-structured firms and a negative effect on the performance of mechanistically-structured firms (Covin and Slevin, 1988). Healthcare as a whole can be generally regarded as risk-averse and passive hierarchical organization, which is by definition not “an entrepreneurial firm”. However, within the Norwegian hospital institutions, the researchers are inclined to favor changes and innovation in order to obtain competitive advantages and compete aggressively with international scientists. The research environment can be characterized as flexible, informal, authority vested in situational expertise and facilitate innovations and new ideas. A good “fit” between EO and organic research environment is aligned. Thus the top management with strong EO in the research environment can enhance the organizational performance. The top management is the main driving force for medical innovation in the country. The case of PCM adoption demonstrates how they collectively promote the adoption of innovative technology; make a customized technology in research environment ready for clinic implementation. This is an efficient pathway for the high-tech adoption in the Norwegian healthcare.

Innovation characteristics can influence the adoption. The more complex and more divergent interests between the stakeholders and the management, the slower technology adoption will be. For instance, the users of PCM technology include a variety of professional groups who practice with their own organizational cultures, agendas, and questions. We can expect the usual conflicts around mobilization of resources and coordination of effort around technology adoption to be intensified. We gained access to the PCM technology through the purchase of a sequencing technology and building up own sustainable competence along practice. The high technology expertise is required for customizing and developing the technology. So far, this is a strong researcher-driven process. How this manner of technology access and the interaction between

organizational and innovation characteristics will influence the tech adoption and implementation trajectory in clinical entity deserve further research.

Connections between organizations are generally regarded as adoption facilitating factors (Rye and Kimberly, 2007). Higher levels of each of these connections (or in the case of network position, a more central or dominant) would facilitate the adoption. Normative and institutional pressures may facilitate the adoption to a greater extent for the later adopters than for the earlier adopters. Social and cognitive boundaries between medical professions and researchers contribute to the slow spread of innovations. Greater network interaction and centrality are hypothesized to be associated with an increased likelihood of adoption. Network relationships influence organizational adoption at the individual level (Rye and Kimberly, 2007), which can effectively create a bandwagon effect in the organization. Technology champions at higher position in the community as in this case have worked as boundary spanner through their network to promote the PCM adoption from decision-making to actual adoption.

In summary, this narrative analysis provides empirical data about the critical elements that affect innovative technology adoption in the Norwegian specialist healthcare. The case of PCM adoption demonstrates that when a technology champion participation coupling with a top-down, program-based strategy could be an effective mechanism for the technology adoption for high end use in the Norwegian healthcare, especially when competence across multidiscipline needs to be acquired for a complete technology adoption through the technology customization and development, such as the development of a good HIIP. A tight collaboration between research institutions and clinics is a feasible manner for building up our sustainable capability for providing better medical services. In this way, we can efficiently leverage our resources to deliver new services without the requirement of organizational changes. The entrepreneurial-oriented scientists as both technology champions and managers can facilitate to set the national priority and formulation of the technology adoption strategy as a response to the technology development and internal unmet needs. The information from both research and clinic serves as the basis for the technology adoption decision making activity. The loosen connections between multidisciplinary professionals and different organizations including industry can foster entrepreneurial-oriented thinking, therefore favoring the

uptake of new technology. The HOT-fit has been recognized for the initial adoption. The key investigators as technology champions are the vital drivers for technology adoption through developing a framework with a good HOT-fit and implementing a strategy within this framework. The extraordinary environment, including the strategic and legal frameworks, is prepared for the tech adoption in this top-down approach. A more user friendly software and a better user support for data analysis and patient management are demanded for the further technology adoption. The cognitive gap between the early adopters and majority adopters should be remediated through the adequate communication and training by using multiple communication vehicles.

Drawing on this data, we find evidence to support that technology adoption in the healthcare is influenced by the nature of the problem being addressed, the technology, the local adoption system, the health system characteristics and the broad context in which the adoption happens, as proposed by Atun (2009). The nature of the problem being addressed such as social narrative, urgency and socio-economic burdens due to the problem will influence the necessity and rate at which an intervention designed to address it (Atun et al., 2010). New technology is introduced in response to the endogenous and exogenous actions or stimulus. Perceived attributes of technology, such as usefulness, ease of use, trialability and observability will influence the speed and the extent the technology is going to be adopted through intersecting with the local adoption system. The local adoption system refers to key actors and institutions with varied interests, values and power distributions in relation to the technology adoption. Each of these stakeholders has different perception about the benefit and risk related to the technology, consequently different incentive, altitude and role in the process of technology adoption, which will collectively decide the “receptivity” for new technology (Atun et al., 2010). Strong EO of top management is associated with the PCM technology adoption. Alignment of regulatory, organizational, financial factors and social-norms facilitates the PCM adoption.

6. Implications

The following section focuses on the both theoretic and practical implications that this study might lead to.

6.1 Theoretical Implications

We proposed an integrated framework (Figure 3) incorporating the technology adoption, TAM, HOT-fit and stakeholder theory to portrait the pathway of PCM adoption in Norwegian healthcare and point out the critical elements at each phase.

This study provides several implications for researchers: 1) our empirical data indicates a linkage between strong entrepreneurial orientation (EO) and technology adoption in Norwegian healthcare. However, EO is not inherently associated with positive performance. It is therefore interesting to study how the concept of EO could have a moderate effect in relation to a technology adoption or adapt to changes in the context of the large, established, decentralized healthcare system. Under which circumstance (what type of technology, who is engaged at what stage), exercising intrapreneurship can be a practical general model or instrument to promote technology uptake and functional integration in a specific healthcare setting? 2) Top-down intervention is an efficient way for technology uptake in a decentralized healthcare system. There is a need for in-depth understanding of gaps along technology adoption in the different healthcare settings, when a top-down approach is heavily involved.

6.2 Practical Implications

The healthcare system by nature is with high hierarchical structure and standardized procedure, which shape an environment not favoring innovation and new technology. The PCM case provides some practical implications for healthcare executives and policymakers in relation to technology adoption. First, internal attitudes and behaviors associated with EO across differing organizational level and unit can foster innovation and new technology adoption, especially when multi-organizations are involved in acquisition of new technology in healthcare system. EO attitudes can be promoted through strategic management such as developing a supportive culture that embraces changes aligned with the mission of the organization; secondly, invest in early adopters, who will be technology champions. A technology champion, especially the

professional with entrepreneurial-oriented mindset, is of critical importance in every phase for promoting technology adoption; Thirdly, management should empower employees by applying a bottom-up approach rather than solely a top-down approach in the process of product design and technology adoption/implementation; Fourthly, management should engage in extensively information sharing and interactions across organizations to promote a synergetic effect in the process, through for example, collaboration, corporation, educational seminar and courses. The successful cases are powerful in fostering a social environment for innovations.

7. Further Research and Limitations

Although the findings from our in-depth study focusing on Oslo area is representative across the country, in order to draw a nationwide picture on PCM adoption, further investigation should be performed within the other three regions (Bergen, Tromsø and Trondheim), as well as collaboration and synergy between regions. The collaboration and synergy among regions will impact on the continued adoption and dissemination across country. Our current results show a limited collaboration towards clinical use within some regions. This was partly due to the different choice of technology infrastructure and associated difficulty of standardization and results comparison between different technologies. How to make the national platform work in its best synergy on this basis warrants further study.

At present, a higher degree of adoption was observed in research environment comparing to that in clinical setting. The adoption in research is building up core competence for its translational clinical use. A follow-up qualitative research with prolonged time frame following a retrospective history of the adoption and diffusion, especially within clinical settings, will be essential for understanding this whole time-dependent adoption process.

While trying to provide exhaustive empirical data for the case, we are limited regarding to the theoretical research. We expect the information provided in this report to be useful for future expanded theoretical research.

8. References

- ALVAREZ, S. A. & BARNEY, J. B. 2007. Discovery and creation: Alternative theories of entrepreneurial action. *Strategic Entrepreneurship Journal*, 1, 11-26.
- ANDERSON, J. G. 1997. Clearing the way for physicians' use of clinical information systems. *Communications of the ACM*, 40, 83-90.
- ANDERSON, J. G., AYDIN, C. E. & JAY, S. J. 1993. *Evaluating health care information systems: methods and applications*, Sage Publications, Inc.
- ATUN, R., DE JONGH, T., SECCI, F., OHIRI, K. & ADEYI, O. 2010. Integration of targeted health interventions into health systems: a conceptual framework for analysis. *Health Policy and Planning*, 25, 104-111.
- BEAL, G. M. & BOHLEN, J. M. 1957. *The diffusion process*, Agricultural Experiment Station, Iowa State College.
- BERWICK, D. M. 2003. Disseminating innovations in health care. *JAMA: the journal of the American Medical Association*, 289, 1969-1975.
- BONTER, K., DESJARDINS, C., CURRIER, N., PUN, J. & ASHBURY, F. D. 2011. Personalised medicine in Canada: a survey of adoption and practice in oncology, cardiology and family medicine. *BMJ open*, 1.
- BOWER, J. L. & CHRISTENSEN, C. M. 1995. *Disruptive technologies: catching the wave*, Harvard Business Review Video.
- CARSON, D., GILMORE, A., GRONHAUG, K. & PERRY, C. 2001. *Qualitative marketing research*, Sage Publications Limited.
- CHRISTENSEN, C. M., BOHMER, R. & KENAGY, J. 2000. Will disruptive innovations cure health care? *Harvard business review*, 78, 102-112.
- COVIN, J. G. & SLEVIN, D. P. 1991. A conceptual model of entrepreneurship as firm behavior.
- CRESSWELL, K. & SHEIKH, A. 2012. Organizational issues in the implementation and adoption of health information technology innovations: An interpretative review. *International Journal of Medical Informatics*.
- DENIS, J.-L. H., YANN; LANGLEY, ANN; LOZEAU, DANIEL; TROTTIER, LOUISE-HÉLÈNE 2002. Explaining Diffusion Patterns for Complex Health Care Innovations. *Health Care Management Review*, 27, 60-73.
- DIAMANDIS, M., WHITE, N. M. & YOUSEF, G. M. 2010. Personalized medicine: marking a new epoch in cancer patient management. *Molecular Cancer Research*, 8, 1175-1187.
- ETZIONI, A. 1964. *Modern organisations*, Prentice-Hall Englewood Cliffs, NJ.
- FOSS, N. & KLEIN, P. 2008. Entrepreneurship: from opportunity discovery to judgment.
- FOSS, N. J., KLEIN, P. G., KOR, Y. Y. & MAHONEY, J. T. 2008. Entrepreneurship, subjectivism, and the resource - based view: toward a new synthesis. *Strategic Entrepreneurship Journal*, 2, 73-94.
- FREEMAN, R. E. 1984. *Strategic management: A stakeholder approach*, Pitman Boston.
- FRIEDMAN, A. L. & MILES, S. 2002. Developing stakeholder theory. *Journal of Management Studies*, 39, 1-21.
- GINSBURG, G. S. & MCCARTHY, J. J. 2001. Personalized medicine: revolutionizing drug discovery and patient care. *TRENDS in Biotechnology*, 19, 491-496.
- HAGEDOORN, J. 1996. Innovation and entrepreneurship: Schumpeter revisited. *Industrial and Corporate Change*, 5, 883-896.
- HAGEN, T. P. & KAARBØE, O. M. 2006. The Norwegian hospital reform of 2002: central government takes over ownership of public hospitals. *Health policy*, 76, 320-333.
- HILL, C. W. & JONES, T. M. 1992. Stakeholder - agency theory. *Journal of management studies*, 29, 131-154.
- HUDSON, L. A. & OZANNE, J. L. 1988. Alternative ways of seeking knowledge in consumer research. *Journal of Consumer Research*, 508-521.

- JIANG, J. J., MUHANNA, W. A. & KLEIN, G. 2000. User resistance and strategies for promoting acceptance across system types. *Information & Management*, 37, 25-36.
- KITTELSEN, S., ANTHUN, K., KALSETH, B. & KALSETH, J. 2009a. En komparativ analyse av spesialisthelsetjenesten i Finland, Sverige, Danmark og Norge: Aktivitet, ressursbruk og produktivitet 2005-2007. SINTEF-rapport A, 12200
- LEE, Y., KOZAR, K. A. & LARSEN, K. R. T. 2003. The technology acceptance model: Past, present, and future. *The Communications of the Association for Information Systems*, 12, 53.
- LUMPKIN, G. T. & DESS, G. G. 1996. Clarifying the entrepreneurial orientation construct and linking it to performance. *Academy of management Review*, 135-172.
- LYNN, G. S., MORONE, J. G. & PAULSON, A. S. 1996. Marketing and discontinuous innovation. *California management review*, 38, 8-37.
- MCFARLAND, D. J. & HAMILTON, D. 2006. Adding contextual specificity to the technology acceptance model. *Computers in human behavior*, 22, 427-447.
- MISES, L. 1949. Human action: A treatise on economics.
- MITCHELL, R. K., AGLE, B. R. & WOOD, D. J. 1997. Toward a theory of stakeholder identification and salience: Defining the principle of who and what really counts. *Academy of management review*, 853-886.
- MOORE, G. A. 2002. *Crossing the chasm: Marketing and selling disruptive products to mainstream customers*, HarperBusiness.
- MORLAND, B., RINGARD, A. & ROTTINGEN, J. A. 2010. Supporting tough decisions in Norway: a healthcare system approach. *Int J Technol Assess Health Care*, 26, 398-404.
- OLE FRITHJOF NORHEIMA, Ø. E., STEIN A. EVENSENC, MARIT HALVORSEND, KNUT KVERNEBO 2001. Adoption of new health care services in Norway (1993–1997): specialists' self-assessment according to national criteria for priority setting. *Health Policy*, 56, 65-79.
- Roy Bremnes et al. 2011. Nasjonalt satsingsområde kreft: Individuell kreftbehandling basert på genprofil en av egen svulst
http://www.helsesorost.no/fagfolk/forskning/forskningsmidler/Documents/grunnlagsdokument_kreftapr11final.pdf Accessed 04/2013
- National strategy for Biotechnology, Norwegian Research Council, 2011,
<http://www.forskningsradet.no/servlet/Satellite?blobcol=urldata&blobheader=application%2Fpdf&blobheadervalue1=Content-Disposition%3A%3B+filename%3D%22Biotekstrategi2011.pdf%22&blobkey=id&blobtable=MungoBlobs&blobwhere=1274480740790&ssbinary=true> Accessed 03/2013
- Norwegian Health directorate, National Cancer Strategy 2013 –2017: available at
<http://www.oslocancercluster.no/News/tabid/69/articleType/ArticleView/articleId/174/National-Cancer-Strategy-2013-2017-response-to-consultation-draft.aspx> (Accessed 30.12.2012)
- The Patients' Rights Act, 1999. <http://www.ub.uio.no/ujur/ulovdata/lov-19990702-063-eng.pdf>, accessed 03/2013
- PHILLIPS, F. S. & GARMAN, A. N. 2006. Barriers to entrepreneurship in healthcare organizations. *Journal of Health and Human Services Administration*, 472-484.
- PLEASANCE, E. D., CHEETHAM, R. K., STEPHENS, P. J., MCBRIDE, D. J., HUMPHRAY, S. J., GREENMAN, C. D., VARELA, I., LIN, M.-L., ORDÓÑEZ, G. R. & BIGNELL, G. R. 2009. A comprehensive catalogue of somatic mutations from a human cancer genome. *Nature*, 463, 191-196.
- POST, J. E., FREDERICK, W. C., LAWRENCE, A. T. & WEBER, J. 2012. Business and society.

- RAUCH, A., WIKLUND, J., LUMPKIN, G. T. & FRESE, M. 2009. Entrepreneurial orientation and business performance: An assessment of past research and suggestions for the future. *Entrepreneurship Theory and Practice*, 33, 761-787.
- RIFAT, A., GUROL-URGANCI, I. & SHERIDAN, D. 2007. Uptake and diffusion of pharmaceutical innovations in health systems. *International Journal of Innovation Management*, 11, 299-321.
- ROGERS, E. 2008. Diffusion of innovations. New York: Free Press.
- RYE, C. B. & KIMBERLY, J. R. 2007. The Adoption of Innovations by Provider Organizations in Health Care. *Medical Care Research and Review*, 64, 235-278.
- SCHUMPETER, J. A. 1941. Business Cycles: A Theoretical, Historical and Statistical Analysis of the Capitalist Process. *The Review of Politics*, 3, 261-264.
- SUCHMAN, M. C. 1995. Managing legitimacy: Strategic and institutional approaches. *Academy of management review*, 20, 571-610.
- THAKUR, R., HSU, S. H. Y. & FONTENOT, G. 2012. Innovation in healthcare: Issues and future trends. *Journal of Business Research*, 65, 562-569.
- VERYZER JR, R. W. 1998. Discontinuous innovation and the new product development process. *Journal of product innovation management*, 15, 304-321.
- WALES, W., MONSEN, E. & MCKELVIE, A. 2011 The Organizational Pervasiveness of Entrepreneurial Orientation. *ENTREPRENEURSHIP THEORY and PRACTICE*, 895-924.
- WALSH, J. P. 2005. Book Review Essay: Taking Stock of Stakeholder Management. *Academy of Management Review*, 30, 426-438.
- WARTICK, S. L. & MAHON, J. F. 1994. Toward a Substantive Definition of the Corporate Issue Construct A Review and Synthesis of the Literature. *Business & Society*, 33, 293-311.
- WOOD, D. J. & JONES, R. E. 1995. Stakeholder mismatching: A theoretical problem in empirical research on corporate social performance. *International Journal of Organizational Analysis*, 3, 229-267.
- World health report, 2000. Accessed 03/2013
http://en.wikipedia.org/wiki/World_Health_Organization_ranking_of_health_systems
- YARBROUGH, A. K. & SMITH, T. B. 2007. Technology Acceptance among Physicians A New Take on TAM. *Medical Care Research and Review*, 64, 650-672.
- YUSOF, M., STERGIOULAS, L. & ZUGIC, J. 2007. Health information systems adoption: findings from a systematic review. *Studies in health technology and informatics*, 129, 262.
- YUSOF, M. M., KULJIS, J., PAPAFAFEIROPOULOU, A. & STERGIOULAS, L. K. 2008. An evaluation framework for Health Information Systems: human, organization and technology-fit factors (HOT-fit). *International Journal of Medical Informatics*, 77, 386-398.

9. Appendix

1. Case study protocol: to make as many step as operational as possible to ensure reliability.

Case Study Protocol:

- I. Introduction to the case study and purpose of protocol
 - a. Case study research questions, and propositions
 - b. Theoretical framework for the case study from literature review
 - c. Role of the protocol in guiding study
- II. Data collection procedure.
 - a. Select the nominations in the study, contact person and names of sites to be visited
 - b. Data collection plan. Contact each informant via email and telephone to arrange a site visit. Informants are informed with the purpose of the case study and research questions. Interview questions are sent to informants beforehand. Conduct site visit. Audio record interview with interviewee's agreement. Note-taking during interview. Follow-up activities (thank-you letter and additional questions, if any).
- III. Prepare the case study composition.
 - a. Transcribe and analyze the interviews
 - b. Develop hypothetical logic model based on the relevant theoretical framework
 - c. Outline the draft.
- IV. Specific set of questions were raised to individual informant based on the different involvement in the project.

2. Case study database: to keep a good auditability so the same results will be produced if the same procedure is followed. The following table summarize the type of the data used in the study:

Unit Being Characterized	<u>Total System</u>	<u>Intermediate Units</u>	<u>Individuals</u>
	Issues, laws, policies, historical data and Convention reports	Local history, documents, interview with leaders	Interviews
Norwegian healthcare as a whole	Structure, Institutional		
Healthcare region and Hospitals	Structure, Institutional	Behavior properties, communication network	Behavior properties and mindset
Governmental agency	Structure, Institutional	Behavior properties, communication network	
Industry	Structure, Institutional	Behavior properties, communication network	

3. Interview Questions:

Semi-structured interview method was used for collecting primary data for this research. This method allows researcher open to all-round perspectives from the stakeholders, while staying focused on the topic. Based on the role of each stakeholder in the PCM program, various questions were raised in the interview. These questions are listed below:

Questions to leader of NSG:

1. You have led a group suggesting “individualized cancer treatment for all Norwegian patients based on the gene profile of their own tumor”, which is the earliest national initiative for personalized cancer medicine (PCM). What is the rationale behind that initiative?
2. What is the procedure of a sequencing analysis for clinical use? How long does it take in present practice? Is any perceived problem or inconvenience?
3. As a doctor, what are the perceived bottlenecks for implementation of the system national wide? How is doctor involved in the process now?
4. Is it difficult to explain to patient about the PCM concept? How could it be easier? How much do doctors need explain to them?
5. What kind of informatics system/software would you like to have? What are the necessary features in the software? As one of the end-users, how do you involved in the development of the software?
6. As a doctor, what kind of training related to PCM would you like to have? What kind of training has been initiated for doctors now?

Questions to Coordinator of NSG:

1. Within the PCM program, what is the activity scope we are focusing on towards both clinic and research?
2. How is the program organized? How is industry partner involved?
3. What are the challenges for you as a project coordinator?

Questions to PCM program leader:

1. Could you give a short introduction to the project? How was it initiated?
2. What are the major milestones you have reached? What are the major challenges that you have encountered so far? How do you think they could be resolved?
3. What type of technology platform/software you think that would work best for Norwegian system? Why?
4. Adoption and implementation of such a complex innovative technology in the whole healthcare will require high degree fitness between human, technology, organization factors. What have been done in order to promote such fitness within and across organizations?

Question to Industry partner/bioinformatician researchers:

1. What type of technology platform/software you think that would work best for Norwegian system? Why?
2. What kind of informatics system/software would you like to develop? What are the necessary features in the software?
3. What are the major milestones you have reached and what are the major challenges that you have encounter so far? How is it possible to resolve them?
4. Oncologist is one of the end users. How are they involved in the development of the software?

Questions to Biotechnology advisory board:

1. Could you give a short introduction to the project and role of your organization in the project?

2. What are the major concerns for adopting PCM, from Bioteknologinemnda's point of view?
3. How well is the patient right pertaining to PCM protected in Norway? Are the laws/regulations in place for protecting patient's right? What is missing, if any?
4. In your opinion, do we have all the laws/regulations ready in order to adopt PCM? If not, in which area do we need additional work?
5. What are the major milestones you have reached and what are the major challenges that you have encounter so far? How is it possible to resolve them?
6. Recommendations for some public available documents regarding your work and achievement.

Questions to Kreftforeningen:

1. Could you give a short introduction to the project and role of kreftforeningen in the project?
2. From your experience, how well does patient understand/accept the concept about gene, DNA sequencing? How do they perceive the predictive value of PCM?
3. What are the major milestones you have reached and what are the major challenges that you have encounter so far? How is it possible to resolve them?

Questions to Oslo Cancer Cluster:

1. OCC coordinates PCM program. Could you give a short introduction to the program and role of OCC in the PCM?
2. How are industry partners involved in the PCM project?
3. What is the nature, if any, of collaborative effort across communities needed to put this project forward for technology adoption?
4. What are the major milestones you have reached and what are the major challenges that you have encounter so far? How is it possible to resolve them?

Questions to molecular biologist, pathologists, oncologist:

1. How do you use DNA sequencing technology in your work? How are you satisfied with the technology?
2. What are the perceived values of PCM for you as a scientist?
3. As an innovative scientist, how would you perceive the organizational attributes in Norwegian healthcare in terms of fostering innovation?

Questions to Cancer Registration:

1. Could you give a short introduction to the role of cancer registration in the PCM program?
2. What kind of challenges PCM is imposing on cancer registration?